THE MARK OF RELIABILITY

APPLIED TEST SYSTEMS, INC.

348 New Castle Road • P.O. Box 1529 • Butler, PA 16003

TO: LOCKHEED AERONAUTICAL SYSTEMS COMPANY
P.O. NO. ABT2V3470X

INSTRUCTION MANUAL FOR 3210
TUBE FURNACE

ATS NO. D880267

RETURN POSTAGE GUARANTEED

3210, etc.

MP MASTER

MA32801

INSTRUCTION MANUAL FOR 3210 TUBE FURNACE

ATS NO. D880267

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LFE

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3-5770 Controller Wiring
4-4994 Furnace Mounting Assembly

Warranty

INSTRUCTION MANUAL NO. 169F

FURNACE OPERATION

OBSERVE MAXIMUM TEMPERATURE RATING OF

CAUTION 2100° F 1150° (C) CAUTION

REFER TO DATA LABEL

APPLIED TEST SYSTEMS, INC.
348 New Castle Road
P.O. Box 1529
Butler, PA 16003
Phone (412) 283-1212

DECEMBER, 1986 IM 169F

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FURNACES

LABORATORY • TEST

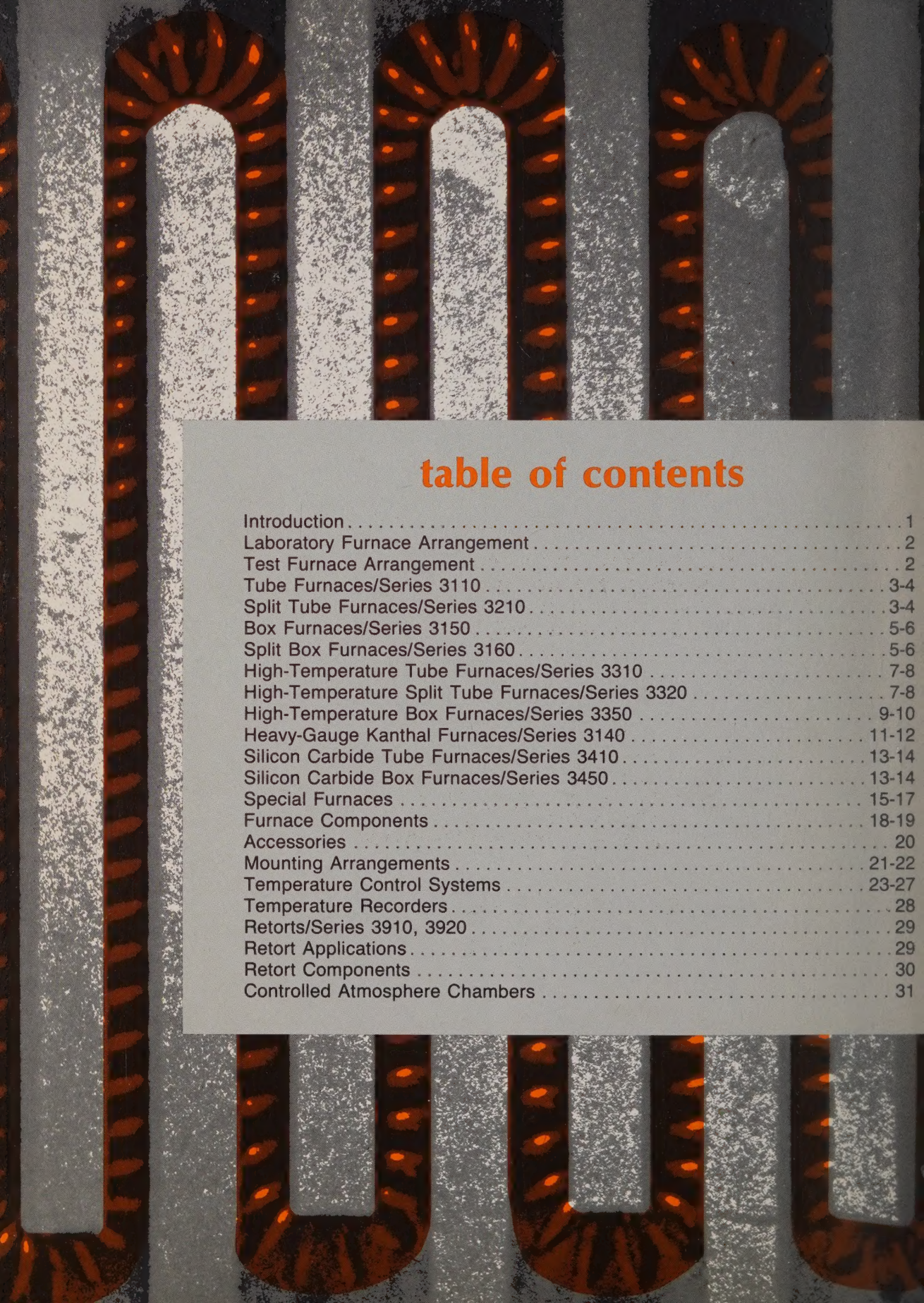
TUBE / SPLIT / BOX / HIGH-TEMPERATURE

- *specials*
- *accessories*
- *controls*

THE MARK OF RELIABILITY

APPLIED TEST SYSTEMS, INC.

bulletin 3110 — 1/87



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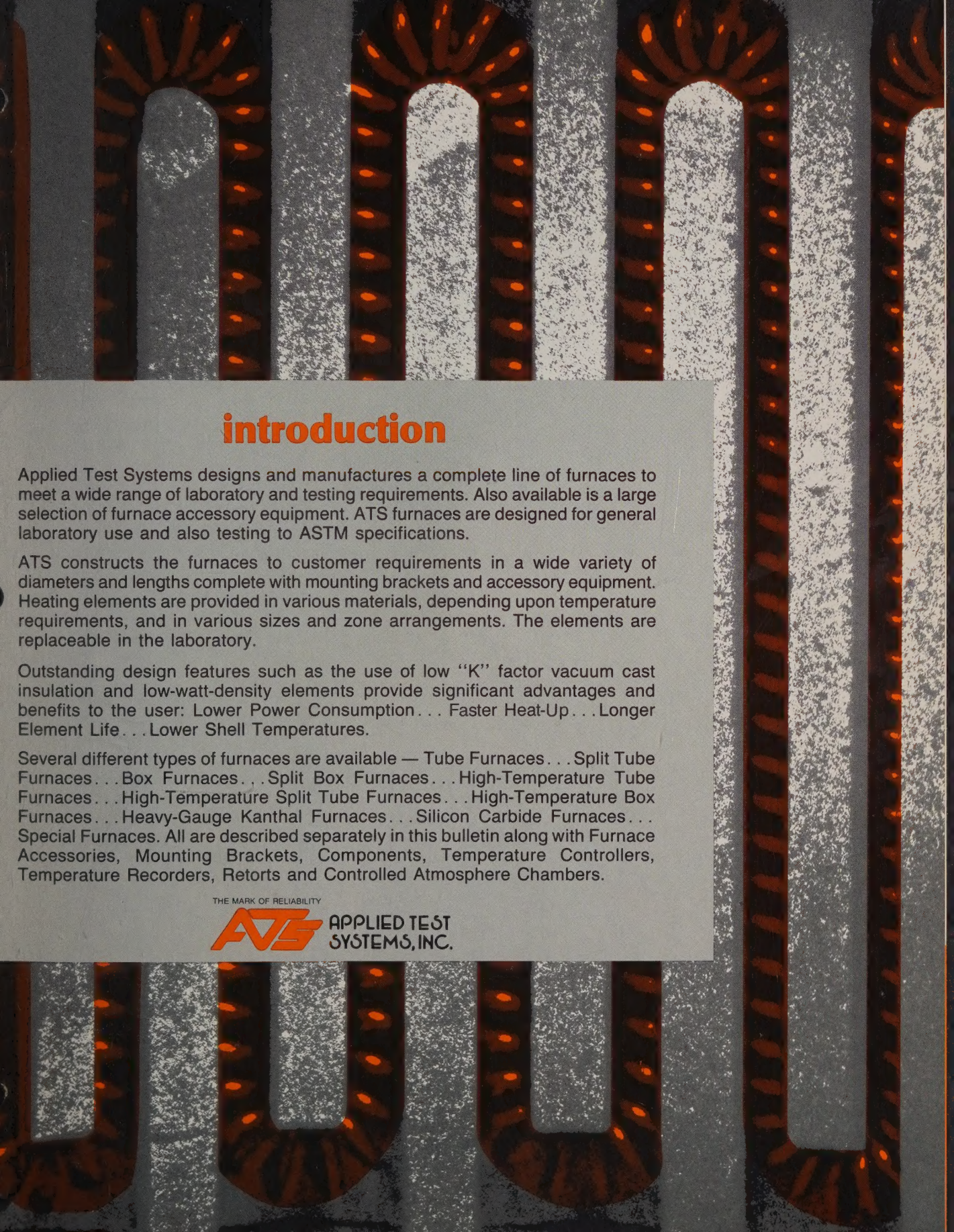


introduction

Applied Test Systems designs and manufactures a complete line of furnaces to meet a wide range of laboratory and testing requirements. Also available is a large selection of furnace accessory equipment. ATS furnaces are designed for general laboratory use and also testing to ASTM specifications.

ATS constructs the furnaces to customer requirements in a wide variety of diameters and lengths complete with mounting brackets and accessory equipment. Heating elements are provided in various materials, depending upon temperature requirements, and in various sizes and zone arrangements. The elements are replaceable in the laboratory.

Outstanding design features such as the use of low "K" factor vacuum cast insulation and low-watt-density elements provide significant advantages and benefits to the user: Lower Power Consumption . . . Faster Heat-Up . . . Longer Element Life . . . Lower Shell Temperatures.

Several different types of furnaces are available — Tube Furnaces . . . Split Tube Furnaces . . . Box Furnaces . . . Split Box Furnaces . . . High-Temperature Tube Furnaces . . . High-Temperature Split Tube Furnaces . . . High-Temperature Box Furnaces . . . Heavy-Gauge Kanthal Furnaces . . . Silicon Carbide Furnaces . . . Special Furnaces. All are described separately in this bulletin along with Furnace Accessories, Mounting Brackets, Components, Temperature Controllers, Temperature Recorders, Retorts and Controlled Atmosphere Chambers.

THE MARK OF RELIABILITY

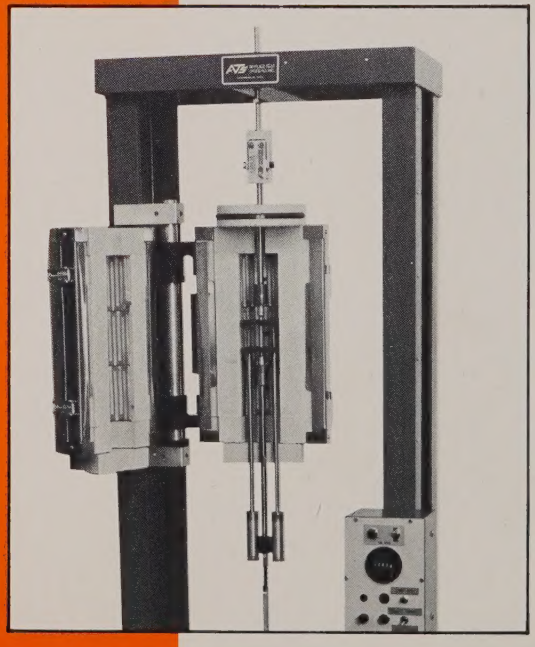
APPLIED TEST SYSTEMS, INC.

laboratory furnace arrangement

Split furnace in a typical laboratory arrangement with baseplate and levelers. Shown equipped with an inconel retort with quick-acting flange cover on upper end.

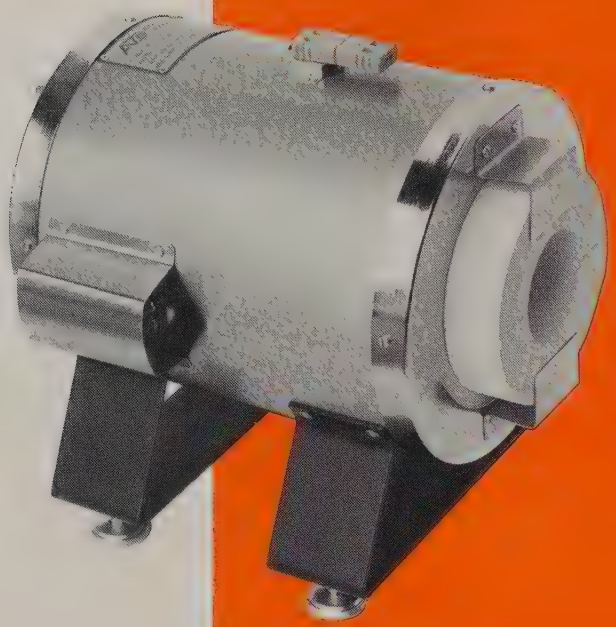
test furnace arrangement

Split furnace with mounting brackets shown in a typical test arrangement in a direct load creep tester.



tube furnaces

SERIES 3110

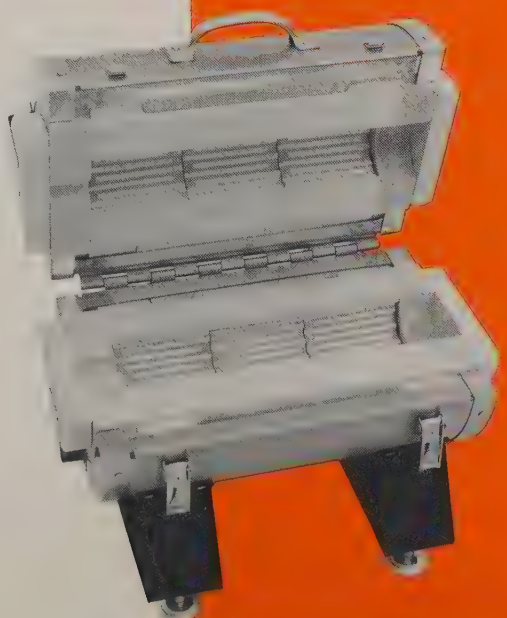


FEATURES

- Furnaces are built to order to customer requirements.
- Wide selection of diameters, lengths, mounting brackets and accessory equipment.
- Constructed with stainless steel shell and nickel-plated steel flanges.
- Low "K" factor vacuum cast ceramic fiber insulation provides minimum heat loss, high temperature capability and rigid structure.
- Heating elements supplied in various materials, sizes and arrangements are replaceable in the laboratory.
- Furnished with adjustable and removable end caps.

split tube furnaces

SERIES 3210



specifications

SERIES 3110/3210

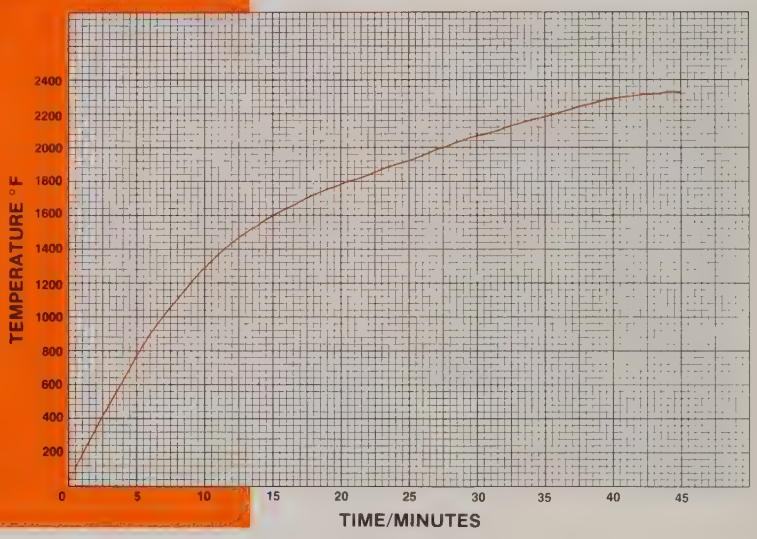
- Other sizes supplied on request.
- Length, Zone Construction: Made to order
- Heating Elements and Temperature Range:
  Nichrome: 1850° F (1010° C)
  Kanthal A1: 2200° F (1204° C)

SPECIFICATIONS - Typical Furnace Sizes			
I.D. x O.D., (in.)	I.D. x O.D., (in.)	I.D. x O.D., (in.)	I.D. x O.D., (in.)
¾ x 5	2⅜ x 8	5 x 14	10 x 16
¾ x 6	2⅜ x 10	5 x 16	10 x 18
¾ x 8	2⅜ x 12	6 x 10	10 x 20
1¼ x 5	2⅜ x 14	6 x 12	10 x 24
1¼ x 6	3 x 8	6 x 14	11½ x 16
1¼ x 8	3 x 10	6 x 16	11½ x 18
1¼ x 10	3 x 12	7 x 12	11½ x 20
1⅝ x 6	3 x 14	7 x 14	11½ x 24
1⅝ x 8	3¾ x 8	7 x 16	12 x 18
1⅝ x 10	3¾ x 10	7 x 18	12 x 20
1⅝ x 12	3¾ x 12	8¼ x 14	12 x 24
2 x 8	3¾ x 14	8¼ x 16	
2 x 10	5 x 10	8¼ x 18	
2 x 12	5 x 12	8¼ x 20	

typical heat-up curve

SERIES 3110/3210

FURNACE SPECIFICATIONS:
3" I.D. 10" O.D. 16" LG
12" H.L./3 Zone/2700 WATTS
No Load



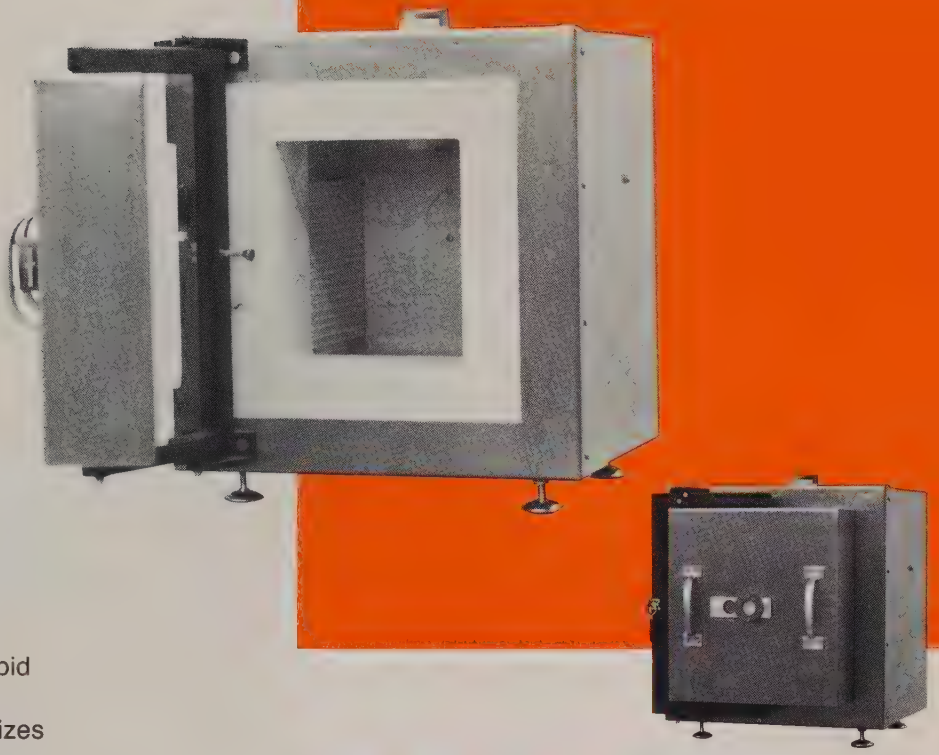
accessories

SERIES 3110/3210

- Temperature Controls
- Control Cabinets
- Recording Systems
- Thermocouples, Terminals and Connectors
- Retorts, Metal or Ceramic
- Controlled Atmosphere Chambers
- View Ports
- Mounting Brackets
- Power Cables and Connectors

box furnaces

SERIES 3150



FEATURES

- Low "K" factor vacuum cast ceramic fiber insulation.
- Low thermal mass permits rapid heat-up and cool-down.
- Wide selection of chamber sizes and zone arrangements.
- Rugged stainless steel case with adjustable latches.
- Available with load train ports and mounting brackets for testing applications.
- Special furnaces constructed to customer requirements.

split box furnaces

SERIES 3160

specifications

SERIES 3150/3160

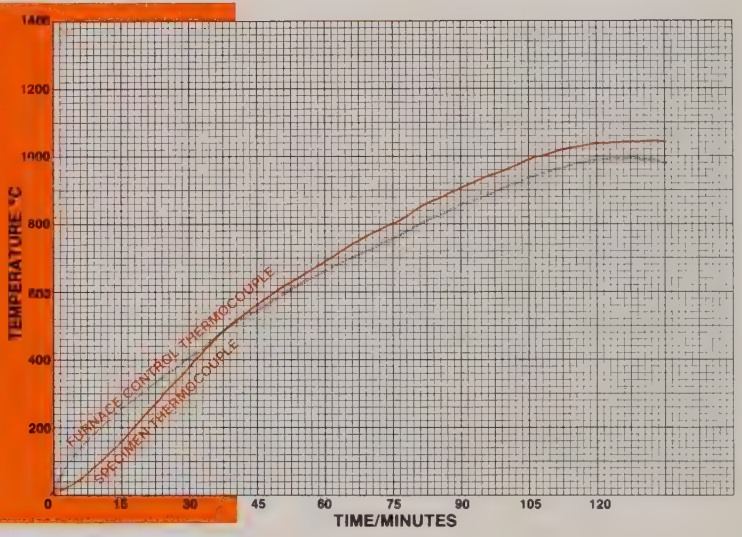
- Other sizes and zone arrangements supplied on request.
- Heating Elements and Temperature Range:
  Nichrome: 1850°F (1010°C)
  Kanthal: 2200°F (1204°C)

3150 Dimensions (in.) Internal			Watts, Approx.		
			Nichrome V Elements	Kanthal A1 Elements	
W	H	D	1850°F/1010°C	2200°F/1204°C	Volts
5½	6½	6	1290	1770	115
5½	6½	12	2070	2460	230
7½	8¾	7	1515	2040	115
7½	8¾	14	3030	4080	230
10	10	12	3750	5100	230
10	10	16	4200	5700	230
12	13½	12	4500	6000	230
12	13½	18	6750	9000	230

3160 Dimensions (in.) Internal				Watts, Approx.		
				Nichrome V Elements	Kanthal A1 Elements	
W	H	D	Zone	1850°F/1010°C	2200°F/1204°C	Volts
6	6	6	1	1720	2360	115 or 230
6	12	6	3	3440	4720	115 or 230
7½	7	7½	1	2020	2720	115 or 230
7½	15	7½	3	4330	5830	115 or 230
10	12	10	1	5000	6600	230
10	18	10	3	7500	9900	230
12	12	12	1	6000	8000	230
12	24	12	3	12000	16000	230

typical heat-up curve

SERIES 3150/3160



accessories

SERIES 3150/3160

- Temperature Controls
- Control Cabinets
- Recording Systems
- Thermocouples, Terminals and Connectors
- Retorts, Metal or Ceramic
- View Ports
- Mounting Brackets
- Power Cables and Connectors

high-temperature tube furnaces

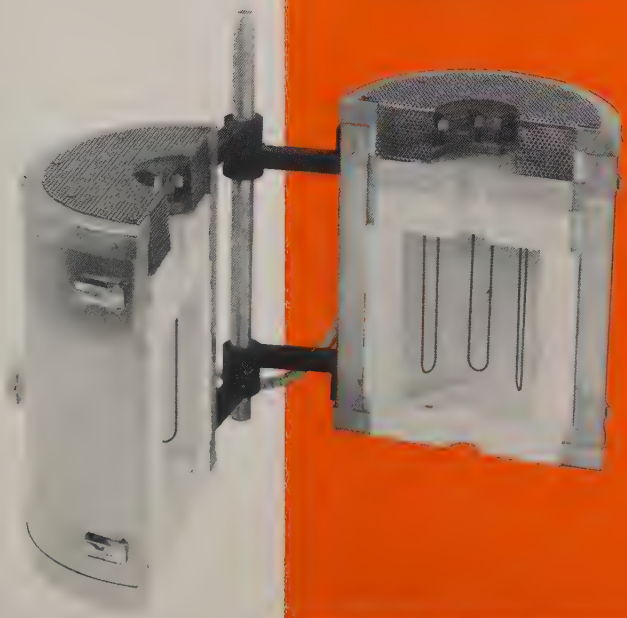
SERIES 3310

FEATURES

- High temperature capability to 3100° F (1700° C).
- Rapid heat-up and cool-down.
- Low "K" factor vacuum cast ceramic fiber insulation.
- Wide selection of diameters, lengths, mounting or support brackets and accessory equipment.
- Furnaces of quality construction with stainless steel shells and nickel plated steel flanges.

high-temperature split tube furnaces

SERIES 3320



specifications

SERIES 3310/3320

- Other sizes supplied on request.
- Heating Elements: Kanthal Super® 33.

Kanthal Super® is a registered trademark of the Kanthal Corporation.

Also available with platinum/rhodium elements in single or multi-zone arrangements.

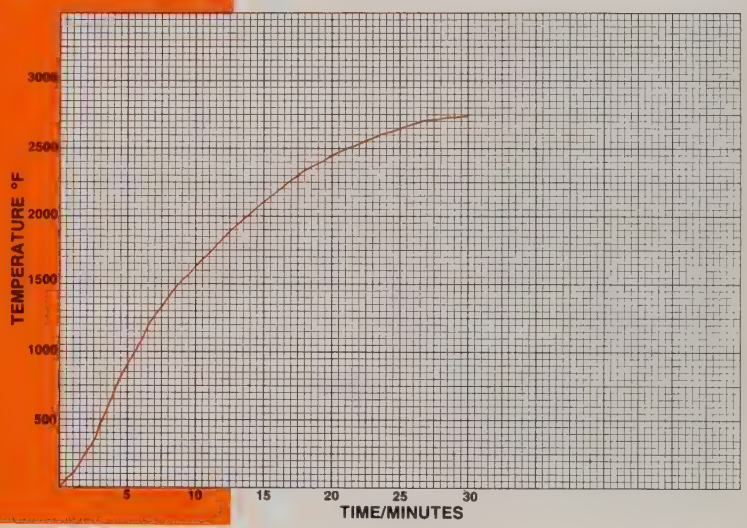
NOTE: These furnaces operate at low voltage and high current, requiring a transformer and current-limiting in the control system.

I.D. (in.)	O.D. (in.) 2800° F	O.D. (in.) 3100° F	Heated Length (in.)	Overall Length (in.)	Watts 2800° F	Watts 3100° F
2	12	14	4	14	940	1620
2	12	14	6	16	1384	2280
2	12	14	8	18	1828	2940
2	12	14	10	20	2272	3600
2	12	14	11	21	2496	3936
4	14	16	4	14	1410	2160
4	14	16	6	16	2076	3040
4	14	16	8	18	2742	3920
4	14	16	10	20	3408	4800
4	14	16	11	21	3744	5248

typical heat-up curve

SERIES 3310/3320

FURNACE SPECIFICATIONS:
2" I.D. 12" O.D. 16" LG
6" H.L./1384 WATTS
2800° F (1540° C)
No Load



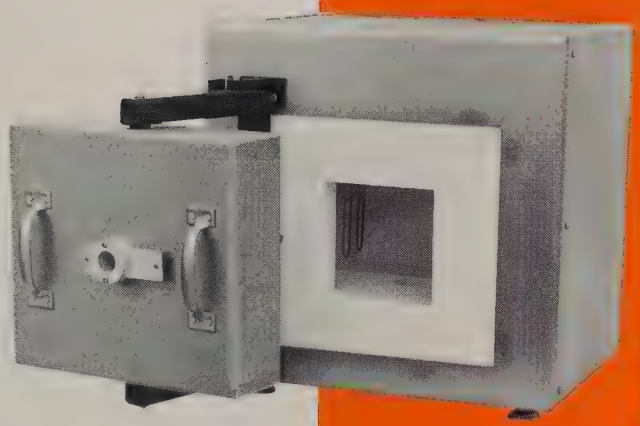
accessories

SERIES 3310/3320

- Temperature Controls
- Control Cabinets
- Recording Systems
- Thermocouples, Terminals and Connectors
- Retorts, Metal or Ceramic
- View Ports
- Mounting Brackets
- Power Cables and Connectors

high-temperature box furnaces

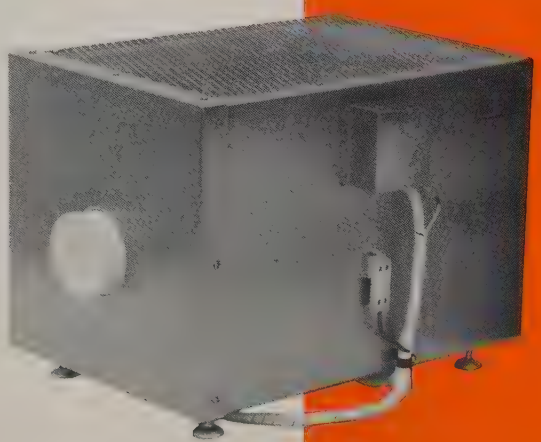
SERIES 3350



FEATURES

- High temperature capability to 3100° F (1700° C).
- Rapid heat-up and cool-down.
- Low "K" factor vacuum cast ceramic fiber insulation, composite materials to provide high temperature capability.
- Wide selection of sizes.
- Single or double-end construction, with or without doors.
- Rugged stainless steel case construction.
- Special furnaces constructed to customer specifications.

HORIZONTAL WITH TUBE



specifications

SERIES 3350

- Other sizes and arrangements including multi-zone, supplied on request.
- Heating Elements: Kanthal Super® 33.

Kanthal Super® is a registered trademark of the Kanthal Corporation.

NOTE: These furnaces operate at low voltage and high current, requiring a transformer and current-limiting in the control system.

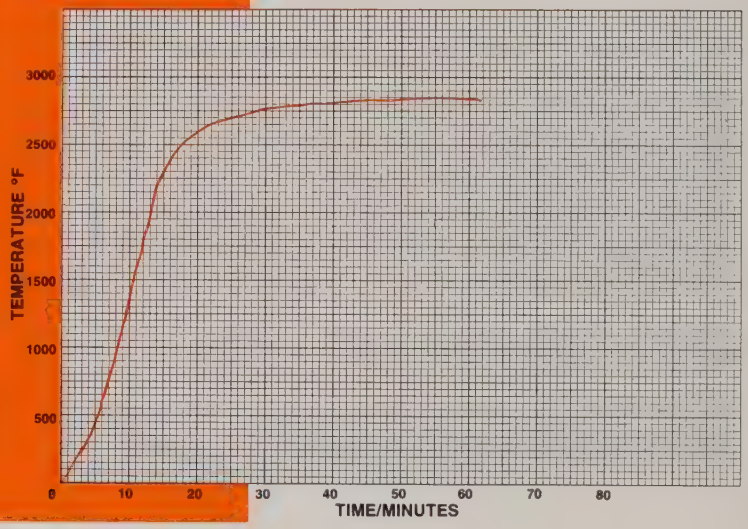
*Internal (in.)			** External (in.)			Watts	Trans-former	Amps
W	H	D	W	H	D			
4	4	6	16	15½	16½	1410	120/40	20
4	4	12	16	15½	22½	2820	120/60	30
6	6	7	18	17½	17½	2768	240/60	20
6	6	14	18	17½	24½	4844	240/120	30
8	8	9	20	19½	19½	4570	240/120	20
8	8	18	20	19½	28½	8226	240/240	40
10	10	11	22	21½	21½	6816	240/240	30
10	10	22	22	21½	31½	12496	480/240	30
12	12	13	24	23½	23½	8736	480/240	20
12	12	26	24	23½	24½	16224	480/480	40

*Useful work volume
**Dimensions are larger for 3100° F furnace.

typical heat-up curve

SERIES 3350

FURNACE SPECIFICATIONS:
6"W x 6"H x 7"D
2800° F (1540° C)
No Load



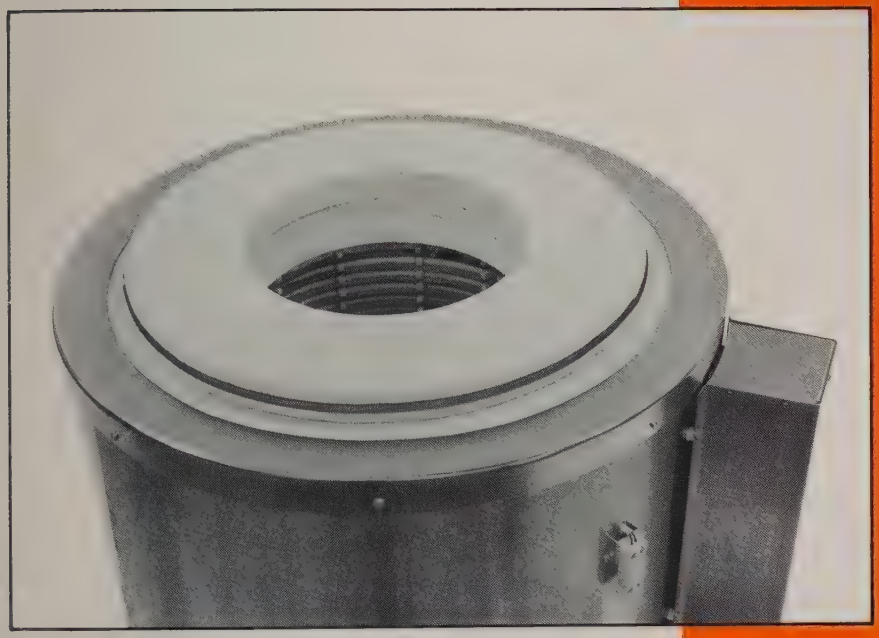
accessories

SERIES 3350

- Temperature Controls
- Control Cabinets
- Recording Systems
- Thermocouples, Terminals and Connectors
- Retorts, Metal or Ceramic
- View Ports
- Mounting Brackets
- Power Cables and Connectors

heavy-gauge Kanthal furnaces

SERIES 3140



FEATURES

- Operating temperature to 2372° F (1300° C).
- Built to customer requirements.
- Low "K" factor vacuum cast ceramic fiber insulation.
- Wide selection of diameters, lengths, mounting brackets and accessory equipment.
- Constructed with stainless steel shell and nickel-plated steel flanges.
- Furnished with adjustable and removable end caps.

specifications

SERIES 3140

- Other sizes built to customer specifications.
- Suitable for either vertical or horizontal operation.

NOTE: These furnaces operate at low voltage and high current, requiring a transformer in the control system.

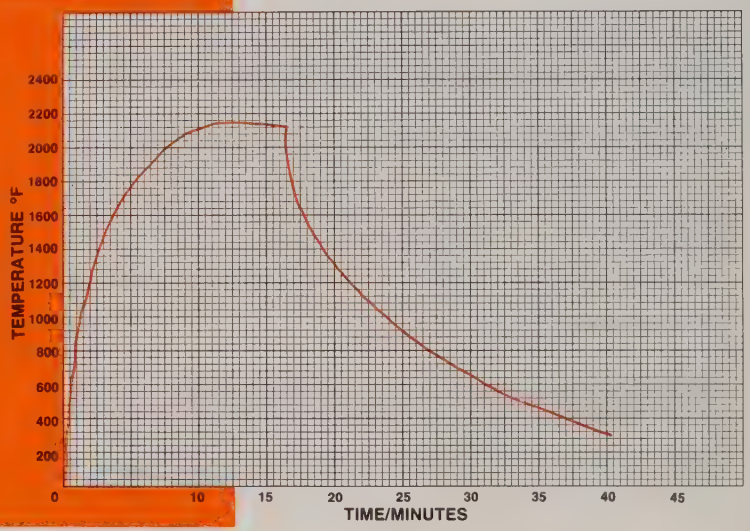
Heavy guage Kanthal elements for 2372°F. (1300°C.) operation.
-Electrical Power: 115 or 230 VAC, 1 ph. supply power.

ID (in.)	HL (in.)	OL (in.)	OD (in.)	Watts Total	Zones
2	9	13	12	1600	1
3	9	13	12	2046	3
4	12	16	14	2400	3
6	12	16	14	3800	1

typical heat-up/cool-down curve

SERIES 3140

FURNACE SPECIFICATIONS:
3" I.D. 12" O.D. 13" LG
9" H.L./3 Zone/2550 WATTS
No Load



accessories

SERIES 3140

- Temperature Controls
- Control Cabinets
- Recording Systems
- Thermocouples, Terminals and Connectors
- Retorts, Metal or Ceramic
- View Ports
- Mounting Brackets
- Power Cables and Connectors

silicon carbide furnaces

TUBE SERIES 3410 (Not Shown)
SPLIT TUBE SERIES 3420

FEATURES

- Operating temperatures to 1500°C. (2732°F.).
- Built to customer requirements.
- Low "K" factor vacuum cast ceramic fiber insulation.
- Wide selection of diameters, lengths, mounting brackets and accessory equipment.
- Constructed with stainless steel shell and nickel-plated steel flanges.
- Furnished with adjustable and removeable end caps.

silicon carbide box furnaces

SERIES 3450

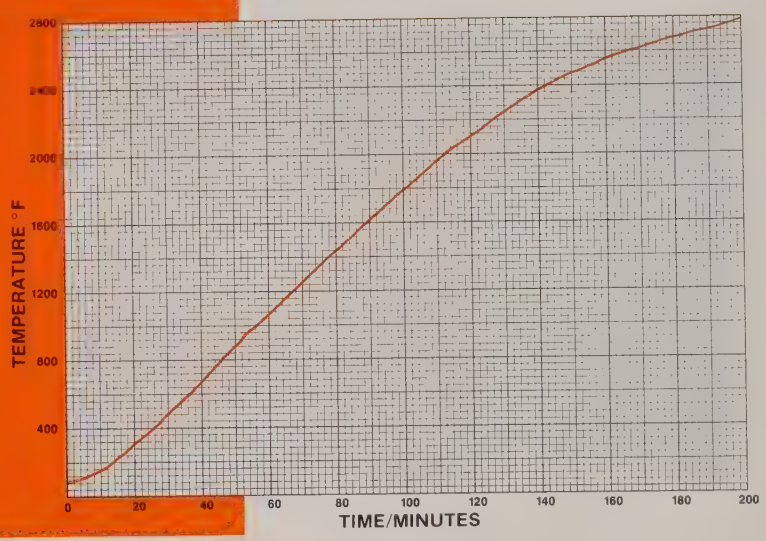
specifications

SERIES 3410

ATS silicon carbide furnaces are constructed similar to the Series 3310, 3320 and 3350 high-temperature furnaces illustrated on pages 8, 9 of this bulletin.

typical heat-up curve

SERIES 3410



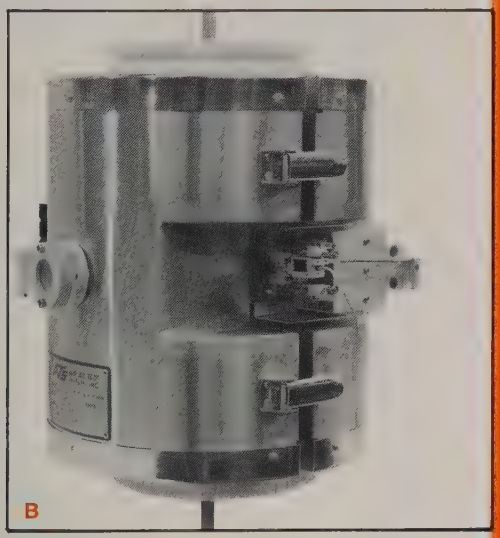
accessories

SERIES 3410

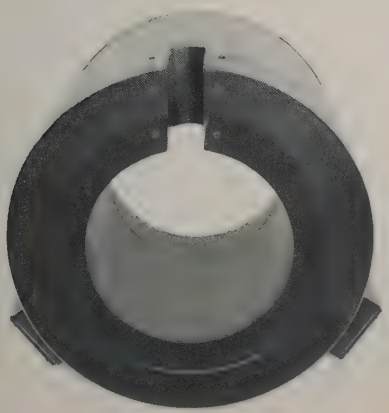
- Temperature Controls
- Control Cabinets
- Recording Systems
- Thermocouples, Terminals and Connectors
- Retorts, Metal or Ceramic
- View Ports
- Mounting Brackets
- Power Cables and Connectors

special furnaces

A



B



C

In addition to suppling furnaces for a wide range of standard applications, ATS provides furnaces to customer specifications for many special applications.

Some of the special application furnaces are illustrated in the following pages.

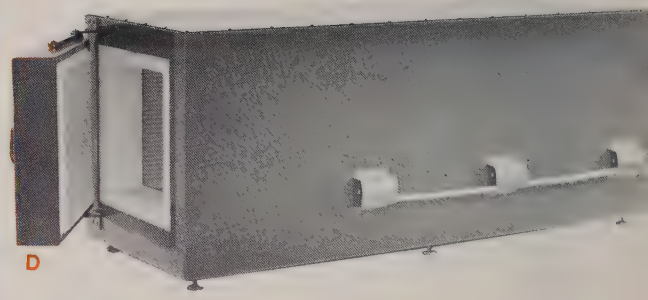
A) Multi-zone split furnace with independent suspension for each half on trolley wheels, providing easy access to the workpiece.

B) Split furnace with side-entry extensometer cutout.

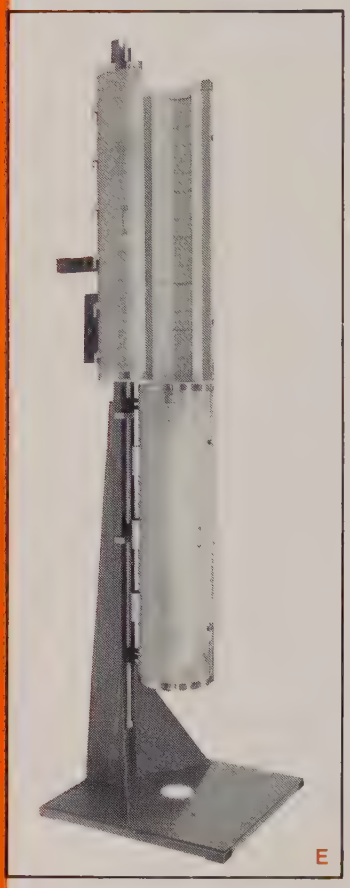
C) Series 3110 furnace with stainless steel liner.

special furnaces

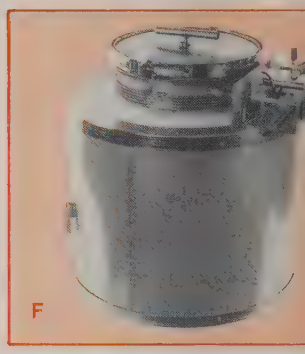
D) Three-zone Series 3150 box furnace with 16-in. zones.



E)Two (2) Series 3210 split tube furnaces, each with 6-zone construction. Mounted on tandem vertical support fixture.

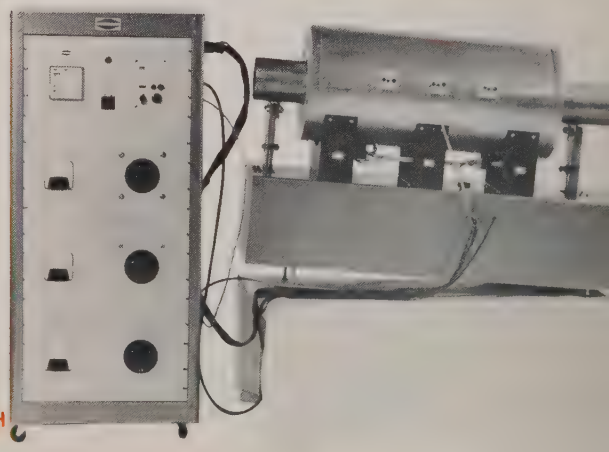


F) Tube furnace with retort, quick-acting flange assembly and gas lines and valves.

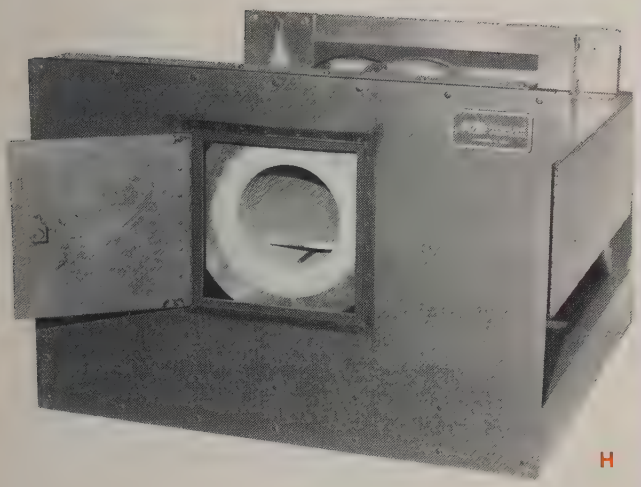


G) Split tube furnace with 2-zone arrangement mounted on baseplate assembly.

H) Series 3110 tube furnace and rotating inconel tube with variable speed drive and adjustable slope. Complete with 3-zone temperature control system.

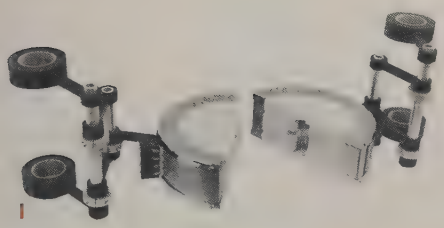


special furnaces



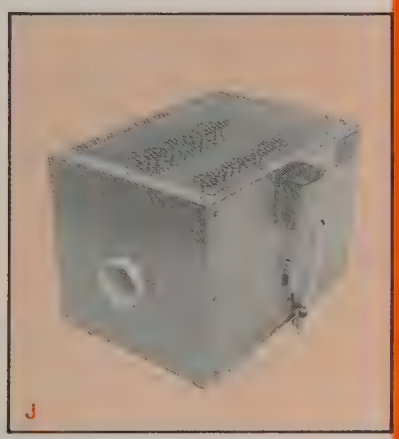
H

H) Tube furnace with non-magnetic housing and 300-gauss permanent magnet. Used to polarize wafers at annealing temperature in a gas-filled retort.



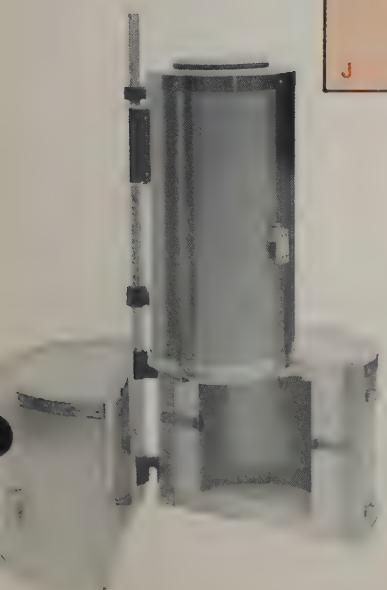
I

I) Compact 2-zone split furnace with mounting brackets. Used to heat specimens to 1800°F. in a low-cycle fatigue tester.



J

J) Series 3350 high-temperature horizontal box furnace with ceramic tube.

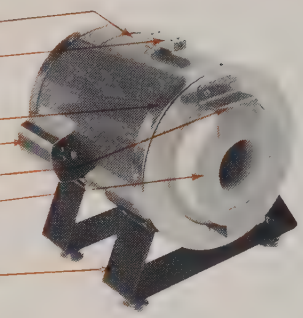


K

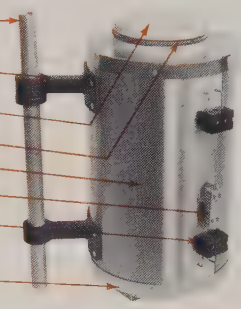
K) Tandem tube over split tube furnace system. With upper tube furnace used as a pre-heater for material dropped onto specimens in the lower funace with stainless steel interior.

furnace components

TUBE FURNACES

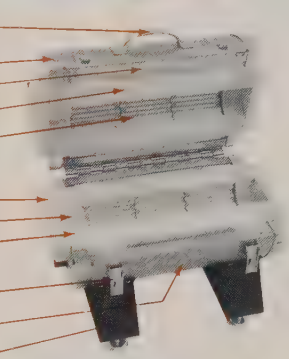


- Stainless Steel Shell
- Thermocouple*
- Nickel-Plated Steel Flanges
- Terminal Cover
- End Cap Retainer
- End Cap Bore
- Support Bracket with Leveling Screws*

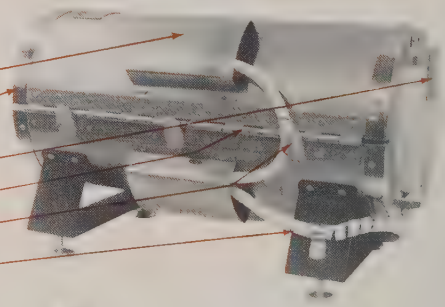


- Mounting Bar*
- Mounting Bracket*
- End Cap
- End Cap Retainer Spring
- Stainless Steel Shell
- Thermocouple*
- Terminal Block
- Nickel-Plated Steel Flanges

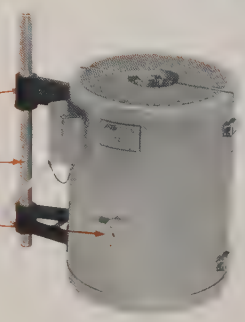
SPLIT TUBE FURNACES



- Handle
- Nickel-Plated Steel Flanges
- Face Board Retainer
- Face Board
- Heating Elements
- Removeable End Cap
- End Bore
- End Disk
- Adjustable Nickel-Plated Latch
- Stainless Steel Shell
- Support Brackets with Levelers



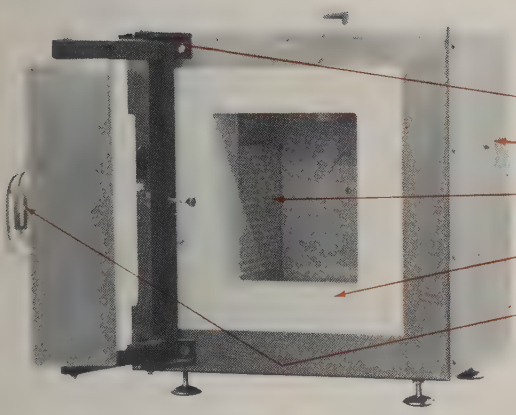
- Terminal Cover
- Nickel-Plated Steel Flanges
- End Cap Retainer
- Continuous Hinge
- Hinge Stops
- Power Cable*



- Mounting Bracket*
- Mounting Bar*
- Quartz View Port*

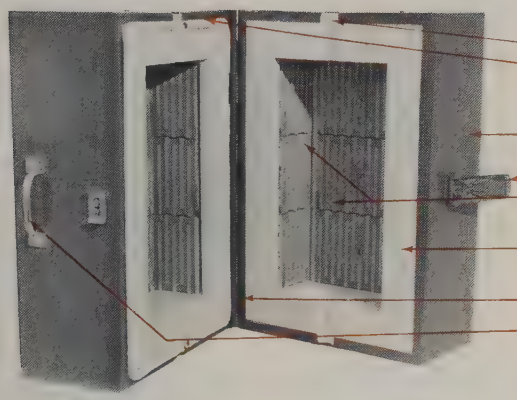
(*optional accessory)

components



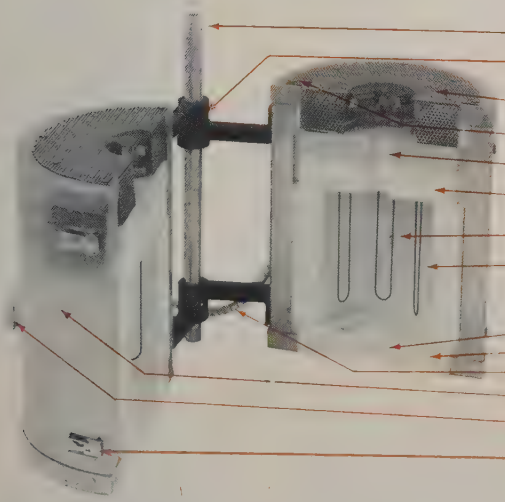
- Double-Pivot Door Hinge
- Stainless Steel Case
- Heating Elements
- Vacuum Cast Ceramic Fiber Insulation
- Handle

BOX FURNACES



- Load Train Port
- Tubular Woven Refractory Door Gasket
- Stainless Steel Case
- Adjustable Draw Latch
- Replaceable Heating Elements
- Vacuum Cast Ceramic Fiber Insulation
- Continuous Hinge
- Handle

SPLIT BOX FURNACES

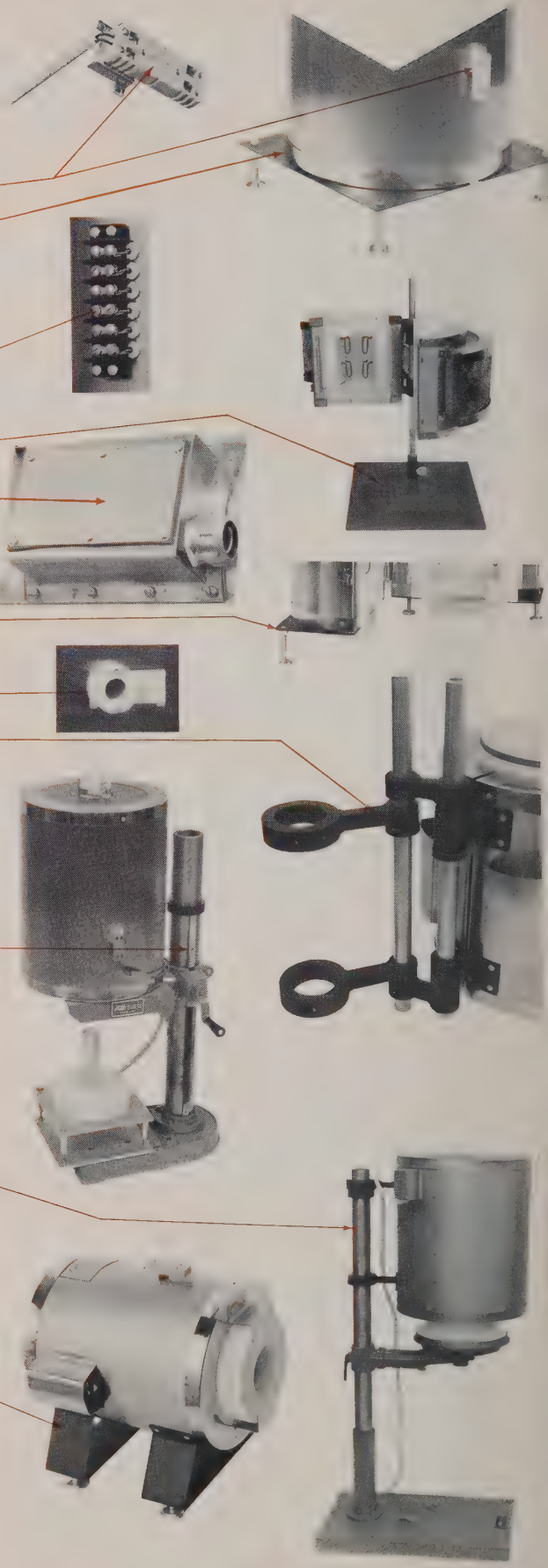


- Mounting Bar*
- Mounting Bracket*
- Stainless Steel Screen
- Nickel-Plated Steel Flanges
- Upper End Bore
- Upper End Disk
- Thermocouple*
- Kanthal Super® 33 Heating Elements
- Lower End Bore
- Lower End Disk
- Power Cable*
- Stainless Steel Shell
- Quartz View Port*
- Nickel-Plated Adjustable Latches

(*optional accessory)

HIGH TEMPERATURE FURNACES

accessories



Thermocouple with connector and mounting bracket.

Base plate with levelers and tube furnace.

Terminal block, installed.

Baseplate with furnace bar.

Sealed terminal cover.

Split base plate with levelers and split furnace.

Quartz view port

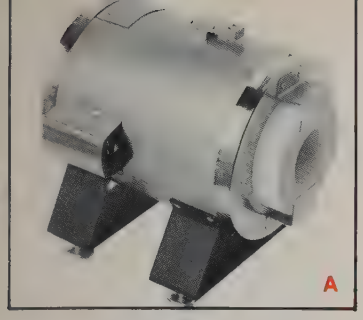
Mounting brackets and bars, double pivot arrangement.

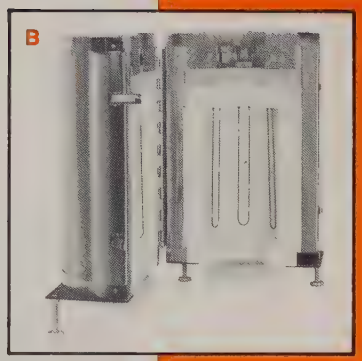
Adjustable stand which permits bottom loading of tube furnace by lowering furnace onto base.

Series 3320 high-temperature tube furnace with vertical adjustment mechanism for bottom loading.

Support brackets with levelers and tube furnace. Used without levelers for vertical mounting.

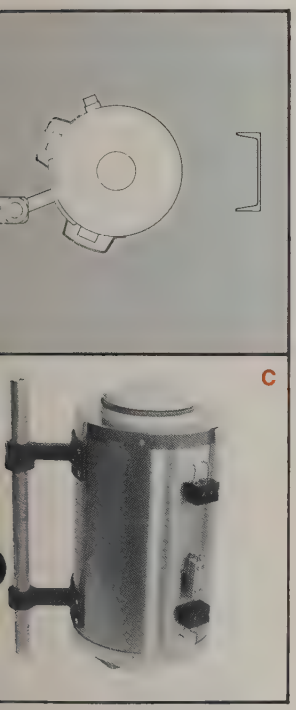
mounting arrangements

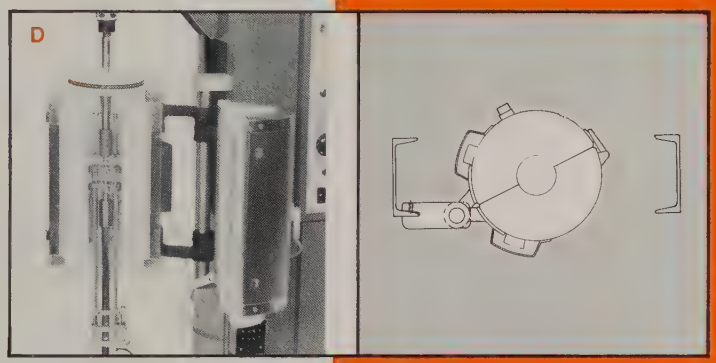




A) Support brackets with levelers. Also used for vertical mounting without levelers.

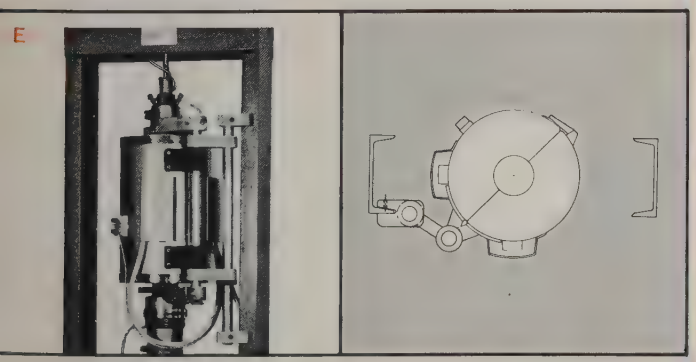
B) Split base plate with levelers on split laboratory furnace.



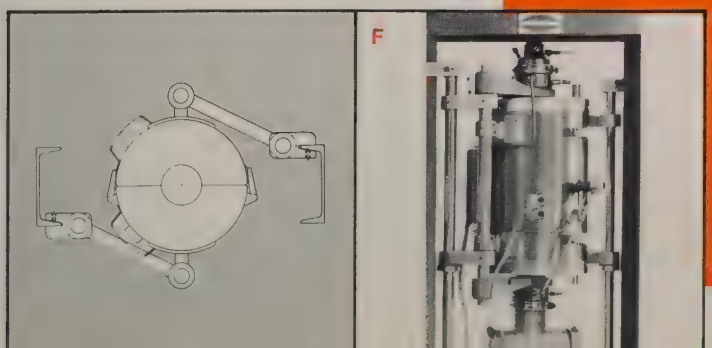


C) Tube furnace mounting bracket and bar.

D) Split furnace mounting bracket bar and split furnace, installed on testing system.



E) Split furnace mounting bracket with dual pivot, providing adjustable center spacing.



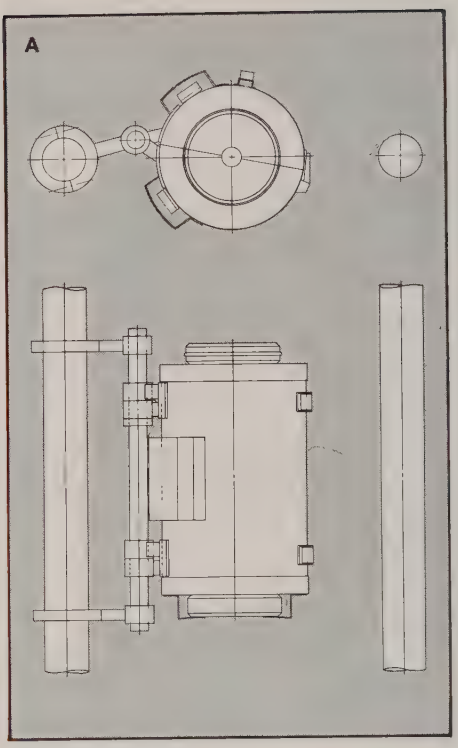
F) Dual mounting brackets, each with dual pivot for split test furnace.

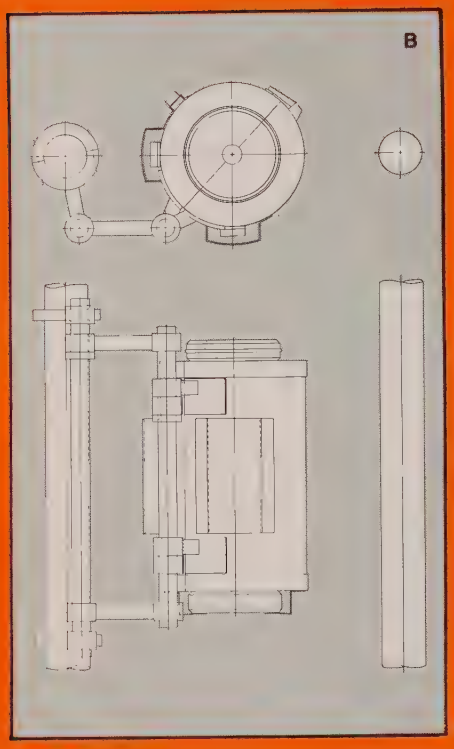
NOTE: Mounting arrangements available LH or RH.

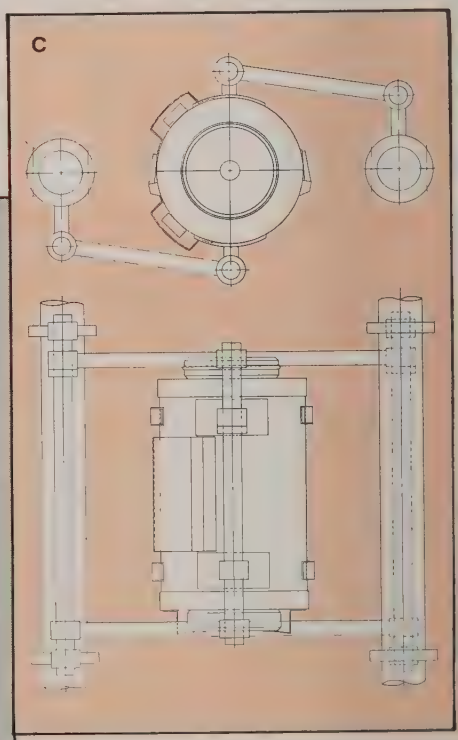
mounting arrangements

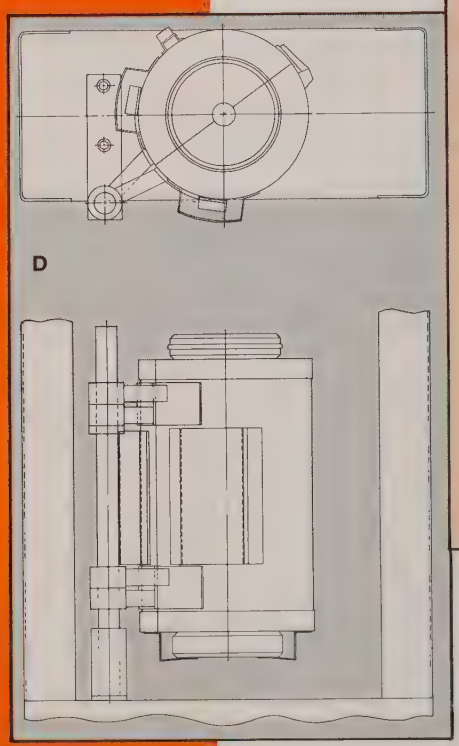
A) Split furnace mounting bracket with furnace bar and column clamps.

B) Split furnace mounting bracket with double pivot, two furnace bars and column clamps.









C) Dual mounting brackets with double pivot, four furnace bars and column clamps for a split furnace.

D) Split furnace mounting bracket with furnace bar and base support bracket.

temperature control systems

SERIES 3820

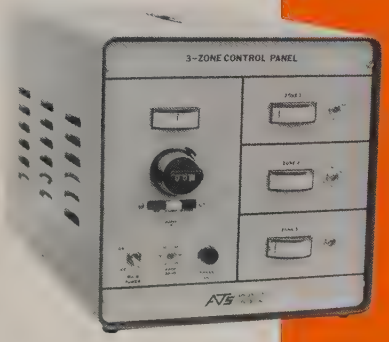
The ATS Series 3820 temperature control systems provide advanced features with economy. They are offered in different types to accommodate a variety of applications.

SERIES 3821 Control System

Time proportioning controller including modulated power control (20 amp), on-off switch and dual-scale meter with push-to-read analog setpoint. Installed in portable cabinet.

SERIES 3822 Control System

A panel-mount version of the Series 3821, the Series 3822 controller provides time proportioning including modulated power control (10 amp) and dual-scale meter with push-to-read analog setpoint. Installed in front mounting panel enclosure.



SERIES 3823A/D 3-Zone Control System

Three-zone, time proportioning control system with modulated power control, deviation indicator and on-off switch. Furnished with three SCR power controllers, each with power adjusting potentiometer and ammeter providing independent control for each zone. Series 3823A (pictured left) has 10 amp power each zone with analog setpoint. Series 3823D (pictured right) has 10 amp power each zone with digital setpoint.

FEATURES

- Precision control accuracy.
- Time proportioning control with modulated power control.
- Solid state zero crossover switching with optical isolation minimizes noise and provides maximum heater life.

specifications

SERIES 3820

SPECIFICATIONS COMMON TO ALL UNITS: Series 3821, 3821/HC, 3822, 3823A, 3823D	
Input Power Requirements:	5 VA @ 120 or 240 VAC ±10%, 50/60 Hz. Specify
Temperature Rating:	Rating operating conditions: 5°C to 55°C (40°F to 130°F)
Humidity Rating:	Rated operating condition: 0-70% RH
Sensor Break-Protection:	Upscale standard (fail safe) primary output goes "off"
Indication:	Analog: full scale process meter accurate to ±2% of full scale. Digital: deviation meter ±50°C of F accurate to ±10°or F except at null which is ±0.5°C or F.
Rated Control Accuracy:	±1%
Setpoint Resolution:	Analog. . . . . Infinite Digital. . . . . 1°F or 1°C
Repeatability:	±0.2%
Automatic Cold Junction Compensation	
Thermocouple Burnout Protection	
Indicating Lights	

Series 3821 and 3822

- Dual scale meter with mirror scale
- Push-to-read setpoint
- Manual reset, to match control temperature to setpoint

Temperature Ranges (Dual Scale, °F and °C)

Type J	Type K	Types R, S
0-400°F 0-200°C	0-1200°F 0- 600°C	0-3000°F 0-1600°C
0-800°F 0-400°C	0-2000°F 0-1000°C	
0-1200°F 0- 600°C	0-2400°F 0-1300°C	

Series 3823A

- Calibrated analog setpoint with temperature deviation meter ±50°
- Proportional band adjustable on front panel

Temperature Ranges

Type J	Type K	Types R, S
0- 400°F	0-1200°F	0-3000°F
0- 800°F	0-2000°F	
0-1200°F	0-2400°F	
0-1600°F		

Series 3823D

- Calibrated digital setpoint with temperature deviation meter ±50°
- Proportional band adjustable on front panel

Temperature Ranges

Types J, K	Types R,S
0-999°F	0-3000°F
0-999°C	0-1650°C

temperature control systems

SERIES 2000, 2010

These controllers incorporate the latest microprocessor technology and provide the user with high accuracy and reliability at a reasonable price. They are sophisticated, versatile controllers that make tuning, calibration and monitoring easier and more accurate than ever before. These compact solid state controllers provide many innovative features.

SERIES 2010 Single-Zone Control System

Programmable microprocessor controller with single-zone SCR power control, 10, 20, 30 or 40 AMP. Also available with heat/cool feature.

SERIES 2010 Three-Zone Control System with Single Controller

Programmable microprocessor controller with three-zone SCR power control, 10, 20, 30 or 40 AMP.

SERIES 2010 Three-Zone Control System with Three Controllers

Three programmable microprocessor controllers, each with meter and SCR unit, 10, 20, 30 or 40 AMP.

Microprocessor Precision and Versatility

- Compact ¼-DIN size.
- Programmable . . . Specific furnace temperature can be preset to desired durations in up to 8 ramp or soak intervals. (Series 2010 only.)
- Dual output capacity allows controller to go above and below ambient temperatures.
- Multicolor vacuum fluorescent display that provides operator information in an easy-to-read format.
- Step-by-step control of temperatures is quickly performed on an environmentally-sealed touch panel keyboard.
- Memory is fully protected with battery backup in case of power loss.
- Temperatures for up to three zones in a furnace can be individually controlled with a single controller. Additional zones can be ramped as followers with the use of setpoint controllers.

specifications

SERIES 2000, 2010

PERFORMANCE
Accuracy: ±0.2% of T/C range
Repeatability: ±0.5°F
Temperature Stability: 3μV/°C including compensation
Temperature Rating:
Operating: 5°C to 55°C (40°F to 130°F)
Storage: −40°C to 75°C (−40°F to 167°F)
Noise Rejection:
Common Mode: 140db typ. 120db min. @ 60 Hz
Normal Mode: 65db typ. 60db min. @ 60 Hz
Setpoint Resolution: 1° for thermocouple. Optional remote setpoint can be analog or digital
RFI: Less than 0.5% of setpoint at 3m from 5 watt source
Radiation: Meets F.C.C. 79-555
Calibration: Permanent in memory
Input Power: 8 watts typ @ 117VAC
13.5 watts max.
50/60 Hz ± 2 Hz
Battery Backup: Internal lithium battery, 10 yr. life

INPUTS
Operating span set by user via keyboard
User to specify range desired
Input Impedance: 10 megohm minimum
Thermocouples: Type J −200 to +1500°F maximum
Type K 0 to +2500°F maximum
Type T −250 to + 750° maximum
for Types B,E,N,R,S and Tungsten-Rhenium Thermocouples.
User to specify range desired
RTD: 100 ohm Platinum Type 1
−300 to +1500°F, 3 wire connection
Optional 0.1°F resolution available
Current: 4-20mA full scale
Voltage: 0 to 10mV up to 0-5 Volt full scale
Pressure: Differential input 0-10mV with internal 12VDC power to drive 350 ohm bridge
Sensor Break Protection: Display indicates "INPUT OPEN." Primary and secondary outputs go "OFF" and alarms turn "ON"
Temperature Range: Is preprogrammed and should be specified by customer

CONTROL
Proportional Band: 0-200% settable with 1% resolution independent primary and secondary proportional bands 5% proportional band preset unless otherwise set
Cycle Time: 1 to 60 seconds settable with 1 second resolution 15 seconds preset unless otherwise set
Reset (Integral): .01 to 20 R/M settable with .01 R/M resolution Independent primary and secondary reset tuning Reset can be turned off 0.25 R/M preset unless otherwise set
Anit-Reset Windup: Standard, inhibits automatic reset when the process input is outside of the proportional band
Rate (Derivative): .02 to 5 min. settable with .01 min. resolution Independent primary and secondary rate tuning Rate can be turned off. 1.0 min. preset unless otherwise set
ON/OFF Output Deadband: Settable at 0.25, 0.50 and 1.00% of span
AUTO/MANUAL: Bumpless transfer (Series 2010)

DISPLAY
Sealed Vacuum Fluorescent Colored Display containing:
Two rows of 8 each 14 segment alphanumeric characters
Alarm 1 and Alarm 2 indicators
Primary and Secondary OUTPUT indicators
Individual TUN, CAL, REM and MAN status indicators

OUTPUT
Two Independent outputs: primary (1) and secondary (2)
Select from current, voltage and solid-state relay output options:
Current Output: 4 to 20mA into 1K ohm maximum load
Other currents available, contact factory
Voltage Output: 0 to 5VDC into a minimum load at 1K ohm
Other voltages available, contact factory
Internal Solid-state Relay: Optically isolated Form "A" Contacts
0.03 to 1.0 amp @ 240VAC option

ALARM (Series 2010, standard/Series 2000, optional)
Two Independent alarms: Can be process or deviation type Form "C" contacts rated 1.0 amp @ 240VAC resistive load
Alarm 1 and Alarm 2 settable to 1 degree resolution
Deviation alarm is always slaved to the primary setpoint

INTERNAL OPTIONS (Series 2010)
Multisetpoint: Preset up to 9 independent setpoints
Ramp and Soak: Program up to 8 ramp times and 8 soak Temperatures with up to 256 repeat cycles
Ramp times selectable up to 100 hours each

THERMOCOUPLE DATA

TYPE	THERMOCOUPLE	RECOMMENDED TEMPERATURE RANGE
T	Copper/Constantan, 20 ga.	32 to 740°F (0 to 390°C)
E	Chromel/Constantan, 20 ga.	32 to 1610°F (0 to 870°C)
J	Iron/Constantan, 20 ga.	32 to 1400°F (0 to 760°C)
K	Chromel/Alumel, 14 ga.	32 to 2480°F (0 to 1360°C)
Platinel II	Platinel, 24 ga.	32 to 2500°F (0 to 1375°C)
S	Pt./Pt. 10% Rh., 24 ga.	32 to 3180°F (0 to 1750°C)
R	Pt./Pt. 13% Rh., 24 ga.	200 to 3200°F (90 to 1760°C)
B	Pt., 6% Rh./Pt., 30% Rh., 24 ga.	600 to 3260°F (310 to 1790°C)

CONTROL CABINETS

Control cabinet, including installation of power leads, connector and 19 in. rack mount panel (s).	Finish: Medium blue textured enamel, with light blue control panel.
Bench top cabinet	8" W x 12" D x 10" H
Bench top cabinet	11" W x 18" D x 11" H
Bench top cabinet	22" W x 15" D x 12" H
Bench top cabinet	22" W x 17" D x 16" H
Portable cabinet on casters	22" W x 17" D x 50" H
Portable cabinet on casters	22" W x 17" D x 69" H
Portable cabinet on casters	22" W x 17" D x 78" H

temperature control systems

Honeywell DCP 7700 Digital Control Programmer

- Microprocessor-based for extended capability
- Combines a digital programmer and a digital controller in one compact unit.
- Convenient keyboard entry
- Stores 9 different programs
- Selectable soak
- Digital readouts continuously track program

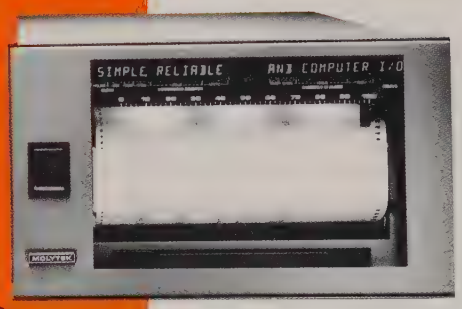
SPECIFICATIONS

Honeywell DCP 7700 Digital Control Programmer	
Inputs	Thermocouples (all types), RTD's, milliamperes, millivolts, volts.
Output	
Current Proportional	4 to 20 mA into 0 to 1000 ohm load.
Time Proportional	SPDT contacts one relay; contacts rated at 120V, 3A. *Relay cycle time:* Adjustable from 2 to 120 seconds.
Time Proportional Heat/Cool	SPDT contacts of two relays; contacts rated at 120V, 3A. *Relay cycle time:* Adjustable from 2 to 120 seconds. *Relay deadband and overlap:* Adjustable from −5 to +5% of output span.
Position Proportional	SPDT contacts of two relays, contacts rated at 120V, 3A. Operates with motors having 100 to 1000 ohms feedback slidewire. *Deadband (motor):* Adjustable from 0.5 to 5%.
Control Constants	*Gain:* Adjustable from 0.1 to 127. Adjustable from 1 to 20 for each output. (Heat Cool model). *Reset:* Adjustable from 0.01 to 50 repeats per minute (off for test) *Reset limits:* Adjustable from −5 to 105% of controller output. *Rate:* Off and adjustable from 0.01 to 10 minutes. *Manual control:* 0 to 100%.
Sampling Rate	*Input:* Sampled every 300 ms. *Output:* Updated every 300 ms.
Stray Rejection Common Mode	*AC (50 or 60 Hz):* 120 db (with maximum source impedance of 100 ohms and maximum voltage of 120 Vac) or ±1 LSB, whichever is greater. *DC:* 120 db (with maximum source impedance of 100 ohms and maximum voltage of 120 Vac or ±1 LSB, whichever is greater. *DC to 1 KHz:* 80 db (with maximum source impedance of 100 ohms and maximum voltage of 50 V) or ±1 LSB, whichever is greater.
Normal Mode	*AC (50 or 60 Hz):* 60 db (with 100% span peak-to-peak maximum).
Time Base (Soak duration and event timing)	*Range:* Adjustable to 999.9 minutes or hours. Selectable for each program entered. *Resolution:* 0.1 minute or 0.1 hour. *Accuracy:* ±0.1% of setting.
Operating Voltage	As specified. 100, 120, 200, 220 or 240 Vac, 50 or 60 Hz.

temperature recorders

32-Channel Recorder/Data Logger (Molytek 2702-S)

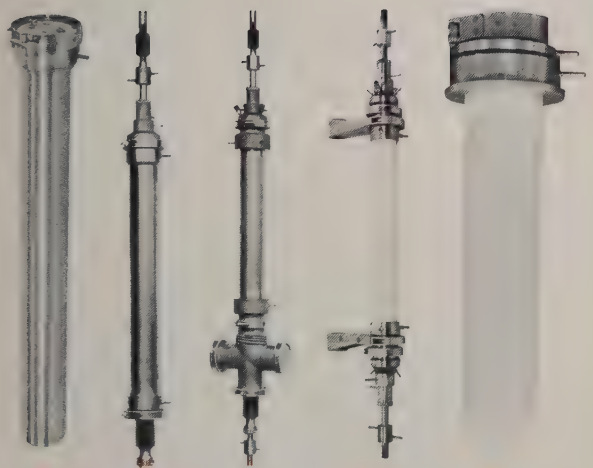
- Computer Interface
- Floating Point Mathematics
- Linearization for 13 T/C and 4 RTD Types
- Programmable Zero and Span from ± 1mv to 10v
- Automatic Calibration Every 2 Seconds



SPECIFICATIONS — Molytek 2702-S

Number of Inputs	Up to 32 analog inputs plus the computer I/O described below in **"computer interface."**
Types of Inputs	Any combination of any of the following types of inputs can be selected by the operator. **Millivolts and volts.** Any full scale voltage from ± 1 millivolt to 10 volts can be programmed. **Milliamps.** 4 to 20mA or other current ranges such as 1 to 5mA or 10 to 50mA can be accommodated by simply installing a resistor across the input terminals. **Thermocouples.** Linearization and automatic cold junction compensation are provided for the thermocouple types J, K, T, R, S, E, B, Nicrosil, Platinel II, W/W-26Rh, W-5Rh, W-3Rh/W-25Rh. In addition, linearization for special thermocouples such as XK, XA, EU-2, LB-3, etc. can be entered by the operator. **Resistance Temperature Detectors (RTDs)** linearization is provided for: Pt-100. Both DIN 43760 (IEC 200385) and Alpha .003923. 120 ohm Nickel. Edison Electric Institute 120 ohm at 0° C 10 ohm Copper. Edison Electric Institute 10 ohm at 0° C JIS 2003916, Pt-50, any other curve can be entered by the customer. **Customer programmed linearizations.** The 2702 has room for 16 different customer entered linearizations for applications such as special thermocouples, RTD, thermistors, humidity sensors, gas analyzers, load cells, flow meters, etc.
Computer Interface	A complete two way RS-232 and passive current loop computer interface is standard in every 2702-S. The computer output contains date and time as well as alarm status, measured variable and engineering units for all channels that are turned 'on.' As an alternative the computer output can be programmed to include only channels that are in alarm and the output can be either continuous or intermittent from once every two seconds up to once per week. Communication is asynchronous; parity and stop bits are programmable and baud rates of 50, 75, 110, 135, 150, 300, 600, 1200, 1800, 2400, 3600, 4800, 7200, 9600, 19,200 can be selected by the operator.
Digital Display	Continuous large character display of time of day plus channel number, alarm status, up to 5 digits of data with + or – sign and engineering unit of any channel.
Accuracy	Better than 0.1% of full scale for all ranges of 10 MV or more. Better than 1% of full scale for 1 MV span.
Automatic Calibration	The 2702 contains a built-in precision reference source and automatically checks both zero and full scale every two (2) seconds and makes adjustments if needed.
Data Logging	The operator may select a 5 column digital printout rather than a trend recording. Input signal data and alarm status for all channels that are turned on plus Date/Time are all printed on the chart in a 5 column format. The frequency of printing is adjustable from once every 12 sec. to once every 5000 minutes. Can also be programmed to automatically interrupt its trend recording with a digital printout of all input signals and then return to trend recording. This switch from trend recording to data log and back to trend can be programmed to occur from once every minute to once every 24 hours and/or whenever an alarm occurs.
Scan Cycle Time	Scans all input signals and alarm set points every two (2) seconds.
Print Cycle Time	All 32 channels can be printed in less than 6 seconds. Channel ID, date, year and time printed at all chart speeds.
Alarm Set Points	The operator can program 2 independent alarm set points for each of the 32 input channels. These can be programmed as high/low, high/high or low/low.
Alarm Chart Speed	The operator may select a slow chart speed for normal operating conditions and a second, faster chart speed for alarm conditions. The faster chart speed will automatically engage whenever one or more channels exceeds a high or low alarm setting and the Date/Time will be printed on the chart. The recorder will return to the slower chart speed when all alarm conditions are cleared.
Chart Speeds	Keyboard selectable from 0.01"/hour to 2"/minute or .01 cm/hr to 300 cm/hr in .01 increments.
Common Mode Voltage	± 15 volt maximum
Input Impedance	Greater than 1 Megohm at D.C.
Dimensions	17.75" (45 cm) wide x 10-½" (26.7 cm) high x 14" (35.5 cm) front to back
Weight	Net 48 lbs. (21.8 kg). Shipping weight 57 lbs. (26 kg).
Power Requirements	Less than 100 watts peak power; 50 watts average power. Rear panel selector switch for 100, 115, 220 or 240 volts. Operates on 50 or 60 Hz.
Warranty	Full two year warranty, parts and labor.

retorts



SERIES 3910
Integral Welded Construction

SERIES 3920
Interchangeable Flange Construction

ATS supplies retorts in a variety of materials including inconel, stainless steel, ceramic (alumina or mullite) and quartz. They are constructed with either integral welded or interchangeable slip-on flanges, the latter making it possible to easily change retort tubes to suit the user's application.

A) SERIES 3910
Inconel retort, closed one end, with ports for vacuum, gas and thermocouples.

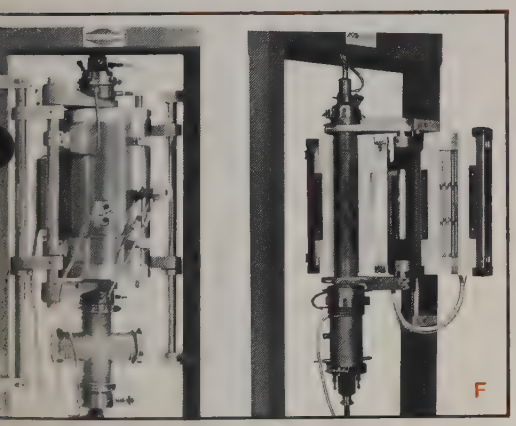
B) SERIES 3910
Inconel retort, welded type, with upper packing gland flange and lower bellows seal flange assembly.

C) SERIES 3920
Inconel retort, interchangeable type, with cross type accessory chamber and flange assemblies for use with testing machines.

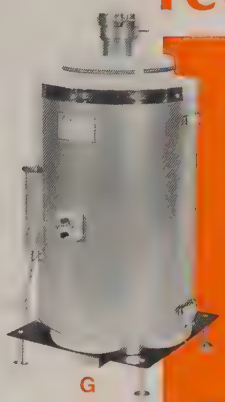
D) Ceramic retort, special construction, with mounting brackets.

E) SERIES 3920
Ceramic retort, closed one end.

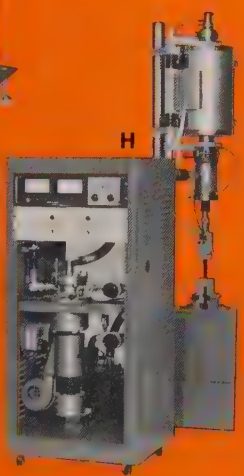
retort applications



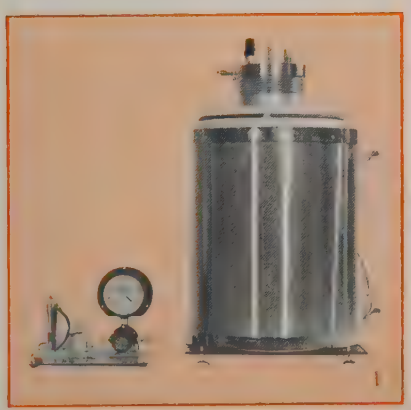
F) SERIES 3910
Inconel retort mounted in split furnace on test machine with crosstype accessory chamber (left) and tube type (right). Shown with mounting brackets, water-cooled pull rods and seals.



G) SERIES 3910
Inconel retort, closed one end, in split furnace with baseplate and levelers.



H) Portable vacuum system and controls with retort, furnace and mounting brackets.

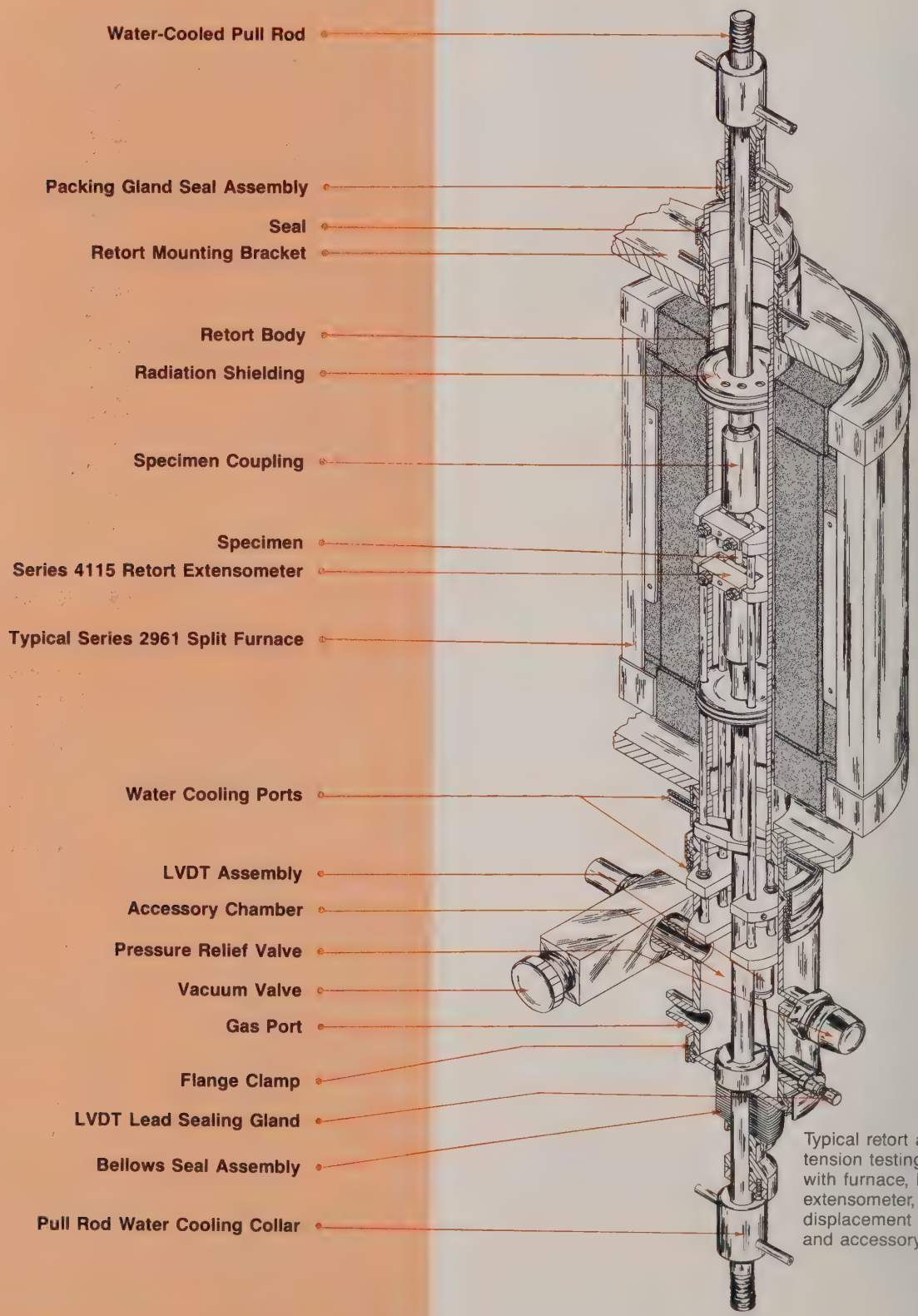


I) SERIES 3910
Inconel retort in tube furnace, used with gas analyzer and purifier.

J) Special ceramic retort furnace with multi-zone molybdenum core.

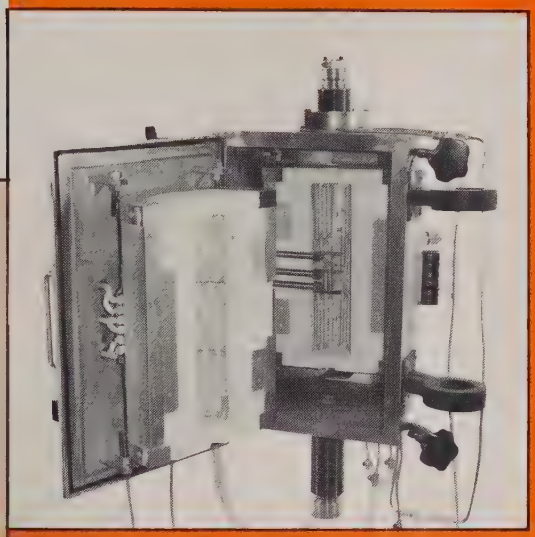
K) SERIES 3910
Inconel retort in tube furnace with inert gas kit.

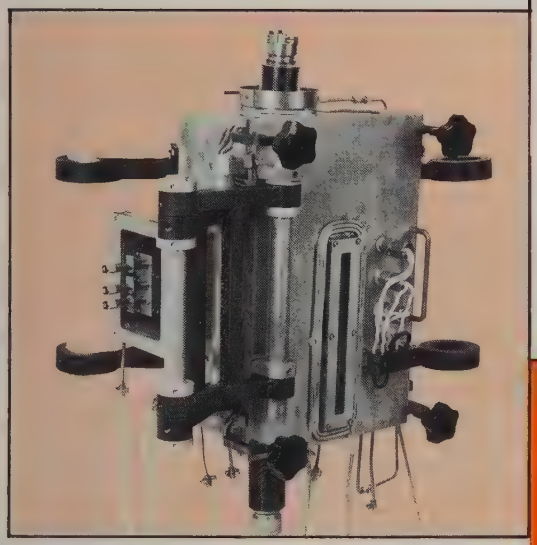
retort components



Typical retort assembly for tension testing. Shown with furnace, load train, extensometer, LVDT displacement transducers and accessory chamber

controlled atmosphere chambers





Controlled atmosphere chamber with mounting brackets, internal split furnace and bellows seals for the load train in a testing machine. Including view port, gland seals and accessory chamber for diametral extensometers. Shown open and closed.

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ATS Has Available A Full Selection of Materials Testing Machines & Accessories To Provide . . .

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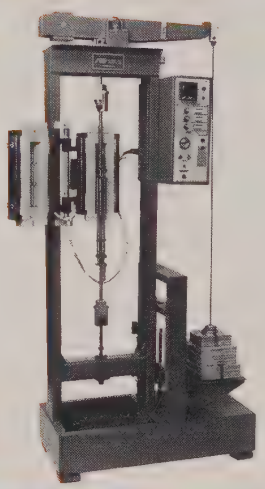
TEST SYSTEMS

- CREEP/STRESS RUPTURE
- STRESS RELAXATION
- CONSTANT STRESS
- ENVIRONMENTAL STRESS RUPTURE

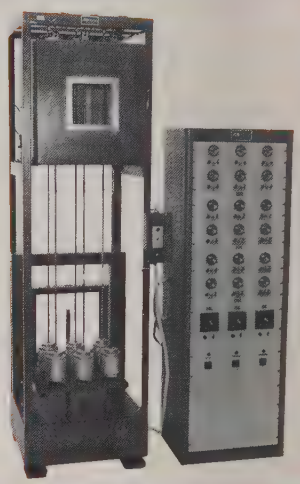
ACCESSORY EQUIPMENT

- Furnaces, Ovens, Temperature Controls
- Retorts, Special Test Chambers
- Extensometers, Displacement Transducers
- Cyclic Load Modules
- Alignment Couplings
- Load Train Components
- Computer Control Systems
- Data Acquisition Systems

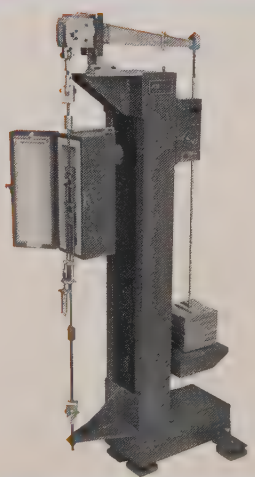
SERIES 2330 LEVER ARM TESTER WITH FURNACE, EXTENSOMETER AND CONTROLS.



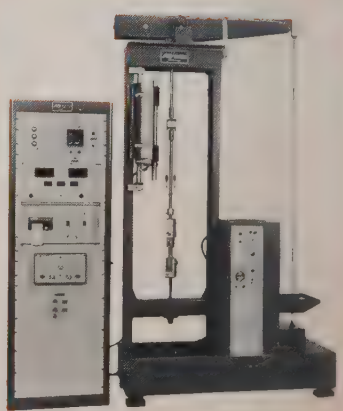
SERIES 2120 6-STATION DIRECT LOAD TESTER WITH TEST OVEN AND CONTROLS.



SERIES 2220 LEVER ARM TESTER WITH WEIGHT ELEVATOR, TEST OVEN, PLASTICS TEST GRIPS AND EXTENSOMETER.



SERIES 2710 STRESS RELAXATION TESTER WITH FURNACE, EXTENSOMETER, CONTROLS AND DIGITAL PRINTER.



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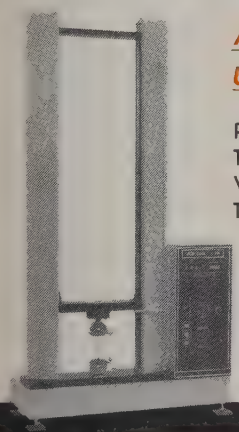
APPLIED TEST SYSTEMS, INC.

OTHER ATS PRODUCTS



ATS Series 1100
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- Modular Construction for Versatility.
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348 New Castle Road • P.O. Box 1529 • Butler, PA 16003
Ph: 412/283-1212 • TLX: 86-6727 ATS BUTLER • FAX: 412-283-6570

1.0 FURNACE DESCRIPTION

1.1 FURNACE SERIES AND TYPE

- 3110 / 2951 Tube Furnace
- 3210 / 2961 Split Tube Furnace
- 3150 Box Furnace
- 3160 Split Box Furnace
- _____

1.2 HEATING ELEMENTS

Material	Windings
-Kanthal A1	-Embedded
-Nichrome V	-Open
-Fecralloy	
-Kanthal Heavy Gauge	
-_____	

1.3 THERMOCOUPLE

- -Type K Chromel/Alumel
- -Platinel II (Type K Compatible)
- -Type J Iron/Constantan
- -_____

1.4 MAXIMUM CONTINUOUS TEMPERATURE RATING

- -2102^{0}F. (1150^{0}C.)
- -2000^{0}F. (1093^{0}C.)
- -_____

1.5 DRAWINGS

- 2-1287 Split Type Furnace
- 2-1338 Tube Type Furnace

2.0 INSTALLATION

2.1 Check embedding on embedded element furnaces. If any spots of the embedding have broken out, use the embedding compound supplied with the furnace. Follow the instructions supplied with the compound on in the element replacement manual.

2.2 Assemble furnace mounting brackets and furnace, and position in testing position (in tester frame, work bench, etc.).

2.3 Adjust furnace position to proper alignment with the load train, retort, etc.

2.4 Install specimen and accessories in furnace.

2.5 Check fit of end caps to minimize heat loss at the ports. Pack blanket insulation around pull rods, extensometer, or retort to seal chamber.

2.6 Connect power from control system to furnace. Use proper size grounding cable to ground furnace to control system and approved grounding source. Refer to local wiring codes. Refer to date label for power requirements. Note parallel or series connections on furnaces that have more than one heating element for zone.

2.7 Connect thermocouple to control system. Use thermocouple type as required for the control system.

NOTE: THERMOCOUPLE EXTENSION CABLES AND CONNECTORS MUST BE COMPATIBLE WITH THE THERMOCOUPLE TYPE BEING USED.

WARNING: FURNACE AND CONTROL SYSTEM MUST BE GROUNDED IN ACCORDANCE WITH LOCAL WIRING REQUIREMENTS.

2.8 Connect power to the control system as listed on the data label.

3.0 FURNACE BAKE OUT INSTRUCTIONS

NOTE: IF THE FURNACE IS EQUIPPED WITH A RETORT, BAKE OUT RETORT WITH FURNACE. VENTILATE RETORT ,SLIGHTLY, DURING BAKE OUT.

NOTE: BAKE OUT SHOULD BE PERFORMED IN A WELL VENTILATED AREA.

3.1 The first time the furnace is fired, heat up to 400^{0}F. (205^{0}C.) with the end caps or door slightly open to provide ventilation..

3.2 Let the furnace soak at 400^{0}F. (205^{0}C.), for approximately two (2) hours, until all traces of water vapor and gases are gone.

3.3 Increase the furnace temperature to 1000^{0}F. (537^{0}C.) (or the furnace rated temperature, whichever is lower). Bake out until smoke and odor are eliminated.

3.4 Increase the temperature to the expected operating temperature and fine tune the temperature control system. (Refer to the manufactures's literature).

WARNING: BE CAREFUL WHEN OPENING FURNACE WHEN HOT, ESCAPING HEAT CAN BURN HANDS AND FACE.

3.5 At the completion of bake out, shut off power and allow furnace to slowly cool (overnight) to 200^{0}F. (93^{0}C.)before opening the furnace.

NOTE: THIS BAKE OUT ONLY NEEDS TO BE DONE ONCE ON NEW FURNACES AND AFTER REPLACEMENT OF INSULATION ON OLDER FURNACES. NO BAKE OUT IS REQUIRED WHEN REPLACING HEATING ELEMENTS.

4.0 OPERATION

After completing furnace setup and connections, set the temperature controlled for the desired temperature. Refer to the manufacturer's instructions for temperature controller operation.

CAUTION: OBSERVE TEMPERATURE CHANGE RESTRICTIONS OF MATERIALS USED (PULL RODS, EXTENSOMETERS, SPECIMEN, RETORT, ETC.). OBSERVE SPECIFIED HEAT-UP AND COOL-DOWN RATES.

5.0 FURNACE SHUT DOWN

WARNING: BE CAREFUL WHEN OPENING FURNACE WHEN HOT, ESCAPING HEAT CAN BURN HANDS AND FACE.

CAUTION: OBSERVE HEAT-UP AND COOL-DOWN RATES FOR ACCESSORY EQUIPMENT, WHEN SPECIFIED.

Shut off power, vent slightly, and allow to cool (overnight) to 200^{0}F. (93^{0}C.)before opening the furnace completely.

6.0 PERFORMANCE TIPS - CAUTIONS

6.1 BE CAREFUL WHEN REMOVING END CAPS OR OPENING FURNACE WHEN HOT, ESCAPING HEAT CAN BURN HANDS AND FACE. WEAR PROTECTIVE EQUIPMENT IF YOU NEED TO OPEN THE FURNACE WHEN HOT.

6.2 HANDLE FURNACE WITH CARE AND AVOID DROPPING. DAMAGE TO ELEMENTS AND INSULATION MAY RESULT.

6.3 DO NOT OPERATE FURNACE IF END BORES ARE NOT PACKED WITH INSULATION. SEVERE DAMAGE CAN RESULT FROM EXCESSIVE ESCAPING HEAT. WHEN USING A RETORT, PROVIDE RADIATION SHIELDING INSIDE THE RETORT JUST OUTSIDE THE HEATED ZONE OF THE FURNACE.

6.4 DO NOT EXCEED MAXIMUM OPERATING TEMPERATURE IN ANY PART OF THE FURNACE. CHECK THE FURNACE DATA TAG FOR THE MAXIMUM TEMPERATURE PERMITTED FOR THE INSULATION OF THE INDIVIDUAL FURNACE.

6.5 KEEP LOAD TRAIN COMPONENTS AS SMALL AS POSSIBLE TO MINIMIZE HEAT TRANSFER.

6.6 KEEP POWER CABLES FROM CONTACTING FURNACE SHELL.

6.7 PACK LOAD TRAIN PORTS AROUND PULL RODS WITH BLANKET INSULATION TO PREVENT HEAT LOSS. BE CAREFUL NOT TO RESTRICT LOAD TRAIN MOTION.

6.8 FURNACE AND TEMPERATURE CONTROL SYSTEM MUST BE GROUNDED ACCORDING TO LOCAL WIRING CODES FOR YOUR AREA.

6.9 SOME INSULATION SHRINKAGE MAY OCCUR AND IS NORMAL. TO ELIMINATE HEAT LOSS AT THIS POINT, STUFF CRACKS WITH A BLANKET INSULATION OF SIMILAR TEMPERATURE RATING (2500^{O}F.)

6.10 WHEN USING OPEN WINDINGS, MAKE SURE THAT NOTHING ELECTRICALLY CONDUCTIVE COMES IN CONTACT WITH THE ELEMENTS WHICH MAY SHORT OUT THE ELEMENTS AND CAUSE POSSIBLE PREMATURE ELEMENT BURNOUT.

7.0 CONTROL THERMOCOUPLE PLACEMENT

The following information is for vertically positioned 2 or 3 zone furnaces used for tensile or stress rupture type testing.

Due to the normal operation of a 2 or 3 zone furnace positioned vertically for use with a tensile or stress rupture type specimen and load train, the furnace control thermocouple will indicate a lower temperature than that of the test specimen. If it is desired to have the control temperature the same as that on the specimen, move the control to the specimen mounted thermocouple.

With the control thermocouple mounted in the heating element, the control system is the most sensitive to heat changes at the heating element. This will keep heat cycling to a minimum. When the control thermocouple is mounted on the specimen, there is a slight lag from when a change in heat output from the heating element(s) reaches the specimen where the temperature change is sensed. This may cause temperature cycling at the specimen.

INSTRUCTION MANUAL NO. 247C

REPLACEMENT OF HEATING ELEMENTS IN SPLIT AND TUBE FURNACES

APPLIED TEST SYSTEMS, INC.
348 New Castle Road
P.O. Box 1529
Butler, PA 16001
Phone (412) 283-1212

APRIL 1987

IM 247C

1.0 INTRODUCTION

Occasionally a furnace heating element will fail and field replacement will be desired. To do so, a suitable work bench is required, and a homemade furnace cradle can greatly aid horizontal support. The basic tools needed are a hammer, punch, screwdriver, wire cutters, adjustable bar clamps, and VOM. The faulty element(s) will need to be located and replacements procured. The furnace should be carefully inspected and any excessively worn or deteriorated part(s) which will affect performance, should be obtained and replaced during the element replacement procedure.

2.0 ELEMENT REPLACEMENT - TUBE FURNACE

2.1 Remove the furnace from testing machine and position on work bench.

2.2 Remove terminal covers and use a VOM to locate burned out element(s). Remove terminal block(s), and straighten wire loops to element(s) that will need to be removed.

2.3 Mark shell and end flanges for assembly alignment. Remove end flange closest to the burned out element. Carefully remove the insulation end board.

2.4 Carefully feed the element lead wires through the shell when removing the required elements. Be careful not to damage the insulation.

2.5 Remove ceramic beads from defective element and save for new elements.

2.6 Carefully feed the element lead wires through the shell when installing the elements.

2.7 Install insulation end board. Align end flange with shell and install. If needed, a bar clamp can be used to compress the assembly enough to allow the screws to be engaged.

2.8 Put ceramic beads in place and use VOM to test for shorts. Reinstall the terminal block, attach the wires to the terminal block, and cut to length. Use a VOM to check for shorts. If shorts are present, locate and correct before operating furnace.

2.9 Install furnace in tester, connect leads, and install terminal covers.

2.10 Follow bake-out procedure supplied in "Furnace Operation" instruction manual.

3.0 ELEMENT REPLACEMENT - SPLIT FURNACE

3.1 Remove the furnace from testing machine and position on work bench.

3.2 Remove terminal covers and use a VOM to locate burned out element(s). Remove terminal block(s), and straighten wire loops to element(s) that will need to be removed.

3.3 Remove end flange form end of furnace nearest to the burned out element. Carefully remove the insulation end board.

3.4 Slide faceboard retainers out open end of furnace. If necessary, use a hammer and punch to carefully drive the retainer out. Carefully remove the faceboards.

3.5 Carefully feed the element lead wires through the shell while removing the required element(s) from the cylinder. Be careful not to damage the insulation. Keep the ceramic beads for the new elements.

3.6 Align wires with the wire paths, feed the wires through the shell, and carefully position the element in place. Align any ports.

3.7 Reinstall the faceboards and slide the faceboard retainers in through the open end of the furnace. If necessary, use a hammer and punch to carefully drive the retainer in place.

3.8 Install the insulation end board. Align end flange with shell and install. If needed, a bar clamp can be used to compress the assembly enough to allow the screws to be engaged.

3.9 Put the ceramic beads in place and use VOM to test for shorts. Reinstall the terminal block, attach the wires to the terminal block, and cut to length. Use a VOM to check for shorts. If shorts are present, locate and correct before operating furnace.

3.10 Install furnace in tester, connect leads, and install terminal covers.

3.11 Follow bake-out procedure supplied in "Furnace Operation" instruction manual.

4.0 FURNACE BAKE-OUT INSTRUCTIONS

NOTE: IF THE FURNACE IS EQUIPPED WITH A RETORT, BAKE OUT RETORT WITH FURNACE. VENTILATE RETORT ,SLIGHTLY, DURING BAKE OUT.

NOTE: BAKE OUT SHOULD BE PERFORMED IN A WELL VENTILATED AREA.

4.1 The first time the furnace is fired, heat up to 400^{0}F. (205^{0}C.) with the end caps or door slightly open to provide ventilation..

4.2 Let the furnace soak at 400^{0}F. (205^{0}C.), for approximately two (2) hours, until all traces of water vapor and gases are gone.

4.3 Increase the furnace temperature to 1000^{0}F. (537^{0}C.) (or the furnace rated temperature, whichever is lower). Bake out until smoke and odor are eliminated.

4.4 Increase the temperature to the expected operating temperature and fine tune the temperature control system. (Refer to the manufactures's literature).

WARNING: BE CAREFUL WHEN OPENING FURNACE WHEN HOT, ESCAPING HEAT CAN BURN HANDS AND FACE.

4.5 At the completion of bake out, shut off power and allow furnace to slowly cool (overnight) to 200^{0}F. (93^{0}C.)before opening the furnace.

NOTE: THIS BAKE OUT ONLY NEEDS TO BE DONE ONCE ON NEW FURNACES AND AFTER REPLACEMENT OF INSULATION ON OLDER FURNACES. NO BAKE OUT IS REQUIRED WHEN REPLACING HEATING ELEMENTS.

5.0 PERFORMANCE TIPS AND CAUTIONS

5.1 WHEN THE FURNACE IS APART FOR ELEMENT REPLACEMENT, REPAIR OR REPLACE LOOSE, BROKEN, OR MISSING PARTS.

5.2 NEVER CONNECT HEATERS FOR OPERATION AT 460 VOLTS BECAUSE OF THE DIELECTRIC STRENGTH OF CERAMICS AT ELEVATED VOLTAGES AND TEMPERATURES.

5.3 REPLACE EXCESSIVELY DETERIORATED INSULATION.

5.4 USE ALL CERAMIC INSULATORS AS SUPPLIED ORIGINALLY TO PREVENT ELECTRICAL SHORTS. USE VOM TO CHECK FOR SHORTS BEFORE APPLYING ELECTRICAL POWER TO FURNACE.

5.5 USE ELEMENTS AND INSULATION THAT MATCH FURNACE RATINGS.

6.0 INSTRUCTIONS TO EMBED (OR PATCH) HEATERS USING ATS EMBEDDING COMPOUND (POWER)

After heaters are in place and leads are fastened, mix power with water into a paste thin enough to go down into the grooves of the heater, but still a rather thick consistency. Work paste down into the groove making sure the cement is going all the way down between the coils. IMMEDIATELY after the coils have been embedded, turn power on heater to dry cement. (This prevents possible rusting of the coils.) When cement turns light grey, it is dry. DO NOT OVERHEAT at this point.

When heater is cool, clean off any excess with a fine emery cloth or sandpaper.

Cement will still be powdery at this time, but will harden as heater comes up to temperature.

SPECIAL INTERCONNECTING WIRING
INSTRUCTIONS FOR ADJACENT SECTION 230 VOLT
HEATER ELEMENTS

FIGURE 1
INCORRECT

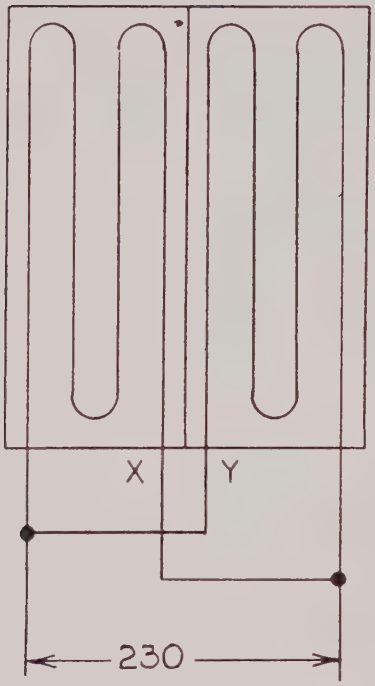


FIGURE 2
CORRECT

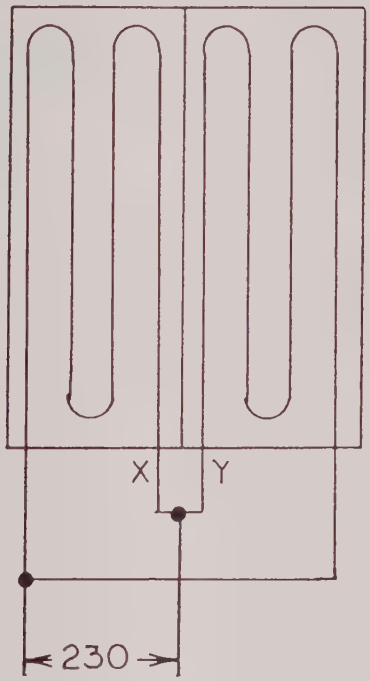


Figure 1 and 2 are examples of heaters that have two adjacent 230 volt heater elements. In figure 1, 230 v appears across points X and Y which are separated by only 1/4 inch of insulation. Heaters with this interconnecting wiring are subject to premature heater failure at elevated temperatures where the ceramic's dielectric strength is weakened. The interconnection shown in figure 2 eliminates the voltage difference between points X and Y for a normal element life expectancy.

INSTRUCTION MANUAL NO. 236B

TEMPERATURE CONTROL SYSTEMS

OPERATION AND MAINTENANCE

APPLIED TEST SYSTEMS, INC.
348 New Castle Road
P.O. Box 1529
Butler, Pa. 16003
Phone (412) 283-1212

JULY, 1987

IM 236B

1.0 CONTROLLER DESCRIPTION

1.1 TEMPERATURE CONTROL SYSTEM TYPE

- Furnace Controller (heat only)
- Oven Controller (heat only)
- Oven Controller (heat/cool)
- _____

1.2 TEMPERATURE CONTROLLER

- LFE 2010/2011 Process Microprocessor
- LFE 2000/2001 Temperature / Process Controller
- _____

1.3 THERMOCOUPLE OR SENSOR TYPE

- Type J - Iron/Constantan
- Type T - Copper/Constantan
- Type K - Chromel/Alumel
- Type E - Chromel/Constantan
- Platinel II (Type K Compatible)
- Type S - Platinum/Platinum - 10% Rhodium
- Type R - Platinum/Platinum - 13% Rhodium
- Type B - Platinum/Platinum - 30% Rhodium
- _____

1.4 TEMPERATURE RANGE

- 70 - 2100° F

Refer to the data label for power requirements and system handling capacity.

2.0 INTRODUCTION

The Applied Test Systems' Temperature Control System controls the amount of power to the resistive heating elements, as required, to achieve and maintain the desired (setpoint) temperature as measured through the control thermocouple. The temperature control system is comprised of a setpoint temperature controller, a solid state power controller, and a matching control thermocouple. A circuit breaker controls electrical power to the system with a pilot light indicating "Power On".

Heat/cool control systems provide cooling control to the oven in addition to heating control.

Additional optional features include:

-High limit alarms and Over-temperature controller.

-Current limit SCR power controller.

-Multiple zone independent control.

Each of these options has a separate manual which is included in the Instruction Manual Assembly, as required.

3.0 INSTALLATION

3.1 Carefully remove the shipping container and packing material from the Temperature Control System. Do not discard the packing materials until all items on the invoice have been accounted for.

3.2 Use the handle(s) on the bench top control systems to remove the system from the shipping container. If the control console is a floor model supplied with casters, install the casters in the cabinet base when the control cabinet is lifted off the shipping pallet. Position the control cabinet in the desired location.

NOTE: THIS SYSTEM IS DESIGNED TO OPERATE IN A NORMAL ATMOSPHERE AT NORMAL ROOM TEMPERATURES. FOR THE BEST ELECTRONIC PERFORMANCE, POSITION THIS SYSTEM AWAY FROM DRAFTS AND AVOID FLUCTUATING TEMPERATURES.

3.3 Connect the interconnecting cables between the heating units (furnace, oven, etc.) and the control console. If cables are not supplied with the system, use wire type SEWF-2 or equivalent. (Follow all local electrical codes.)

CAUTION: FURNACE AND CONTROL SYSTEM MUST BE GROUNDED ACCORDING TO LOCAL WIRING REQUIREMENTS.

Connect the thermocouple to the control system. Use the thermocouple type required by the control system.

NOTE: THERMOCOUPLE EXTENSION CABLES AND CONNECTORS MUST BE COMPATIBLE WITH THE THERMOCOUPLE BEING USED.

3.4 Provide electrical power with ground per requirements on the data label to the terminal block labeled "Customer Power" inside the control cabinet. Follow accepted wiring practices.

4.0 OPERATION

4.1 Turn on "Main Power".

4.2 Turn on "Controller Power". Set up and operate the controller per test requirements. (Refer to the Setpoint Controller for operation of the setpoint controller.)

NOTE: FOLLOW TUNING INSTRUCTIONS IN THE CONTROLLER MANUAL.

4A HEAT/COOL OPERATION - ADDITIONAL CONTROLS AND OPERATION

4A.1 Set the cooling alarm (ALM 2 on LFE Series 2000 Controllers) for the cooling setpoint. The cooling process will be activated above this temperature.

4A.2 Light Switch - The light switch is used to control the light inside the oven chamber (This feature is optional).

5.0 CAUTIONS

5.1 DO NOT BLOCK COOLING VENTS ON THE CONTROL CABINET.

5.2 BEFORE TUNING THE TEMPERATURE CONTROLLER, BE SURE TO READ AND UNDERSTAND THE TUNING INSTRUCTIONS IN THE SETPOINT CONTROLLER MANUAL.

5.3 DO NOT OPERATE THE TEMPERATURE CONTROL SYSTEM IN AMBIENT TEMPERATURES HIGHER THAN 120 DEG.F.(49 DEG. C.) WITHOUT PROVIDING A COOLING FAN OR AIR CONDITIONING.

5.4 DO NOT USE A TEMPERATURE CONTROL SYSTEM WITH A POWER OUTPUT RATING LOWER THAN THE CURRENT RATING OF THE FURNACE.

5.5 USE A TEMPERATURE CONTROL SYSTEM WITH CURRENT LIMITING POWER CONTROLLER FOR FURNACES THAT HAVE HEATING ELEMENTS WHOSE RESISTANCE AT START-UP IS NOMINAL. UNTIL REACHING OPERATIONAL TEMPERATURES, THESE FURNACES DRAW EXCESSIVE AMOUNTS OF CURRENT. (KANTHAL 33, KANTHAL HEAVY GAUGE, SILICON CARBIDE, ET AL.)

5.6 WHEN CHANGING FUSES IN POWER CONTROLLERS WITH CURRENT LIMITING POWER, USE ONLY THE FUSE TYPE AND SIZE SPECIFIED BY THE POWER CONTROLLER MANUFACTURER.

5.7 USE INTERCONNECTING CABLES OF THE PROPER GAUGE TO MATCH THE RATINGS ON THE DATA LABELS FOR THE FURNACE AND CONTROLLER.

5.8 USE THE SAME THERMOCOUPLE AS INDICATED ON THE SETPOINT CONTROLLER. OTHER TYPES WILL RESULT IN FAULTY CONTROL WHICH MAY CAUSE DAMAGE FROM OVERHEATING COMPONENTS.

5.9 USE THERMOCOUPLE EXTENSION WIRES AND CONNECTORS WHICH MATCH THE THERMOCOUPLE TYPE BEING USED. USE OF COPPER WIRES WILL CAUSE ERRORS IN THE READINGS RESULTING IN FAULTY CONTROL.

5.10 THE THERMOCOUPLE PROTECTION TUBE SHOULD NOT PERMIT ANY PART OF THE THERMOCOUPLE TO COME IN CONTACT WITH OTHER METALS. DOING SO WOULD INDUCE INCORRECT VOLTAGES RESULTING IN FAULTY CONTROL.

6.0 MAINTENANCE

To ensure that the equipment functions properly, it is suggested that preventive maintenance be performed at prescribed intervals. Components should be inspected periodically so that any defects can be corrected before they result in degradation or failure. If defects are discovered during operation, make a note of the defect and correct it as soon as operation has ceased. Stop the operation immediately if a deficiency is discovered that could ultimately damage the equipment.

CAUTION: WHEN PERFORMING MAINTENANCE CHECKS AND SERVICING, DISCONNECT POWER. FAILURE TO DO SO COULD RESULT IN SERIOUS INJURY DUE TO ELECTRICAL SHOCK.

6.1 Connectors and cable assemblies - Check wiring and connectors for evidence of bent pins, damaged shells, worn or frayed insulation, and oxidation. Replace damaged parts.

6.2 Components - Inspect components for evidence of physical damage. Replace damaged components.

6.3 Screws, nuts, and bolts - tighten all loose hardware.

7.0 APPENDIX

7A THERMOCOUPLE

The thermocouple essentially consists of two dissimilar metal wires welded together at one end, forming a junction. The opposite ends are connected to the controller. As the welded junction is heated, a voltage is generated, and a current will flow providing an input signal for the control system to monitor and provide operational control. The higher the temperature, the higher the voltage.

The voltage also varies with the chemical composition of the wire. The most predictable and durable of these combinations are classified and used for temperature measurement.

In order to protect the thermocouple elements from oxidation or corrosion at high temperatures, protective sheaths are commonly used. These sheaths also protect the thermocouple from touching any metal surfaces and causing incorrect signals to be induced into the control system.

When replacing thermocouples, the same type must be used. The extension wires and connectors must also be compatible with the thermocouple(s) and controller.

DEALING WITH INTERFERENCE IN ELECTRONIC INSTRUMENTS

Ever since the introduction of electronics into instruments, noise generated by external relays, switches, motors, phase fired thyristors, etc. have caused problems that interfere with the instrument's operation. Now that microprocessors are being increasingly incorporated into many more varied instruments, external sources that generate noise pulses that, in some cases, may render the instrument completely inoperative, have become crucial to instrument applications. While much can be done within the instrument to reduce its sensitivity to external noise, the solution in many cases can only be resolved by supressing the noise generation at its source. The purpose of this bulletin is to identify some of the more common noise sources and to suggest some practical methods for dealing with them.

Noise Sources

Noise is picked up by instruments in three different ways. It may be coupled by (1) a direct connection (even though it may be a very high impedance), (2) a capacitive effect (electrostatic) or (3) an inductive effect (magnetic). The last two of these are the most difficult to trace as they couple current or voltage without any actual physical connection to the equipment.

Some typical examples of noise generating sources that may cause instrument malfunction through capacitive and inductive coupling are:

* Solenoids
* Relay coils
* Heavy current carrying wires and cables
* AC supply wiring - especially above 100 VAC
* Thyristor controllers
* Radio frequency transmitters

Impedance coupled noise may enter the instrument through its connections to the power supply or may be coupled by improper grounding. Most power supply lines conduct a great deal of noise in a typical industrial plant. Although power line noise is generated in many ways, most noise is related

to sources that contain switching circuits. Some examples of these sources are:

* Relays and contactors
* Motor starters
* Electric motors and power tools - especially those with starting switches or brushes
* High intensity discharge lamps
* Welders or any equipment utilizing an arc discharge
* Phase triggered silicon controlled rectifier circuits
* Machines or equipment employing microprocessor or computer electronic control

Methods for Preventing Noise Interference

There are three principle approaches for dealing with electrical noise. The most obvious method is to suppress the noise at its source. While this is the most effective, it is also the most difficult to achieve since it is much more difficult to identify and isolate all of the noise generators in an industrial environment. For this reason, suppression is normally applied after all other potential solutions have been tried and have not resolved the problem.

The second method is to prevent electrical noise from entering the equipment on the signal and power supply lines. Usually this involves proper separation and shielding of the lines to the instrument but may also require power line filtering or, in special cases, connection to a separate power line. The responsibility for good wiring practice lies entirely with the user or installer of the equipment.

The last method is not directly under the control of the user since he must depend on the instrument manufacturer to have designed the proper filters, shields, opto-isolators and suppressors into the equipment to provide a high degree of built-in noise rejection. Most manufacturers perform extensive testing to reduce the equipment's sensitivity to noise.

Wiring for Noise Reduction

While all wiring must conform to national and local codes, such standard practices do not address the noise problems of electronic instruments. Most instrument wiring will fit into three general classes with a number of subclasses as listed on page 3 in table I.

Table I - Wiring Classes

Class	Type	Shielded & Twisted Wires Recommended
A	HIGH VOLTAGE	No
1	Power line	
2	Earth ground	
B	ANALOG I/O	Yes
1	Process variable (Thermocouple, RTD, DC millivolts, etc.)	
2	Low level (< 100V) (4-20 mA, 1-5V, etc.)	
C	DIGITAL I/O	Yes
1	Low voltage (< 100V)	
2	Computer interface	

Prior to installing an instrument, the following recommendations should be reviewed so that it will not be necessary to rewire the installation after noise problems appear:

* Wires carrying the same class of signals (see Table I) may be cabled or bundled together, but wires carrying signals of a different class must be kept separated.
* Twisted and shielded wires are recommended for all Class B and C signals (see Table I).
* For long distances (over 5 feet) and when shielding is recommended, use separate conduits or metal trays for each class bundle. If conduits or trays are not feasible, use twisted wires with a metal overbraid.
* When signals of a different class (see Table I) must cross, either in conduits or trays, they should cross at a right angle and at the maximum spacing practical. Where spacing is not possible, a grounded steel barrier or shield should be installed between unlike levels at crossing points.
* Trays containing Class B or C signal wiring should be metal with solid bottoms, sides and covers. Tray covers should be continuous and have positive contact with the side rails for the maximum shielding effects.
* Wires carrying Class B or C signals should be routed to avoid close proximity to any of the high noise generators listed below:

  contactors and relays
  motors and generators
  transformers
  radio transmitters
  Class A wiring carrying high currents that are switched on and off

* All shields, metal trays and conduits should be grounded at only one end - preferably the instrument end. Grounds should use 16 ga wire or heavier and must be connected to a good earth

ground such as a cold water pipe or metal stake driven into the ground.

The Power Supply

In addition to supplying power within the voltage and frequency ratings of the equipment, the power source for electronic instruments should also be independent of all other loads, especially those which are frequently switched such as air conditioning, motors, or other similar types. Supply circuits should preferably provide electrical isolation by using a separate transformer and a shielded primary and secondary windings may be required. Additionally, where the power supply contains high frequency components, it may also be necessary to add power line filters to attenuate the noise signals on the power line to the equipment.

Noise Suppression at the Source

In most applications in which good wiring practice has been used to power well designed equipment from an independent power supply, no further protection is necessary. There are, however, some environments that are so noisy that the interference must be suppressed at the source. While, when properly done, noise suppression is the most effective, the problems in identifying all of the sources can be taxing especially since each installation may be different and require a separate review of the noise generator sources.

The standard technique for noise suppression is first to review all of the components in the installation and to identify all inductive coils and contacts that break inductive loads. Each of these noise generators must then be suppressed individually using surge suppressors (resistor-capacitor circuits) or voltage limiters (metal oxide varistors) until the noise no longer affects the instrument operation. Each of these two noise producers, inductive coils and contacts, are discussed below:

1. AC Inductive Coils: Metal oxide varistors (MOV's) are recommended for suppressing the high transient surges that result from the collapsing field of an inductor or coil. The MOV is to be connected in parallel with the coil and must be physically located as close to the coil as possible. Additional protection may be supplied by adding an R-C circuit in parallel with the MOV. Refer to Figure 1 for typical circuit connections.

Table II - Recommended MOV Voltage Limiters

Max. AC	Energy Pulse Rating	Suggested Mfgr. or Equiv.
130V	38 Joules	(G.E.) V130LA10A
250V	72 Joules	(G.E.) V250LA20A
510V	190 Joules	(G.E.) V510LA80B

NOTE: MOV's should be selected on the basis of coil voltage and the energy to be dissipated. If a MOV feels excessively hot after several interruptions of power to the coil, a higher energy rating should be used.

Table III - Recommended R-C Suppressor Network

Coil Voltage	Resistor Rating	Capacitor Rating
120V	220 Ohms @ 1/4 Watts	0.5 uF @ 1000V
240V	220 Ohms @ 1 Watts	0.5 uF @ 1000V
460V	220 Ohms @ 3 Watts	0.5 uF @ 1000V
550V	220 Ohms @ 5 Watts	0.5 uF @ 1000V

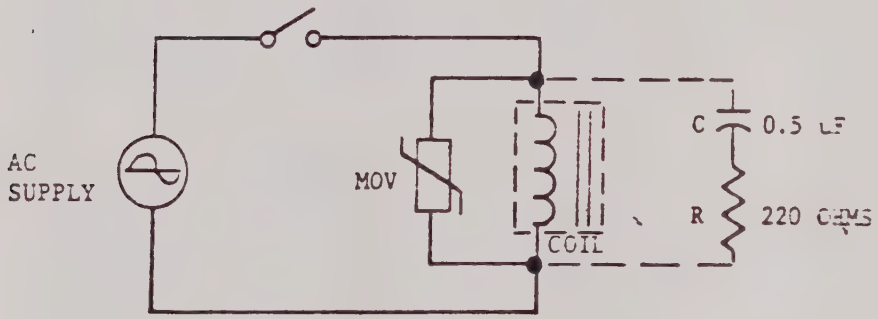


Figure 1 - Typical circuit for the suppression of AC coils

2. DC Inductive Coils: Inductive coils in DC circuits may be suppressed by paralleling a diode and series resistor across the coil. The greatest suppression will be obtained if the resistor is omitted. However, the use of a diode alone will lengthen the time constant of the coil. A good compromise would be to use a resistor in series with the diode equal to the DC resistance of the coil. The diode must have a PIV rating that is greater than the normal DC voltage applied across the coil. See Figure 2 for typical circuit connections.

Caution is recommended when noise suppressing coils used in equipment for controlling brakes, clutches, etc. where the speed of operation is essential to the safe operation of the equipment. Such installations must be carefully checked to ensure that the equipment safety has not been compromised by the noise suppression network.

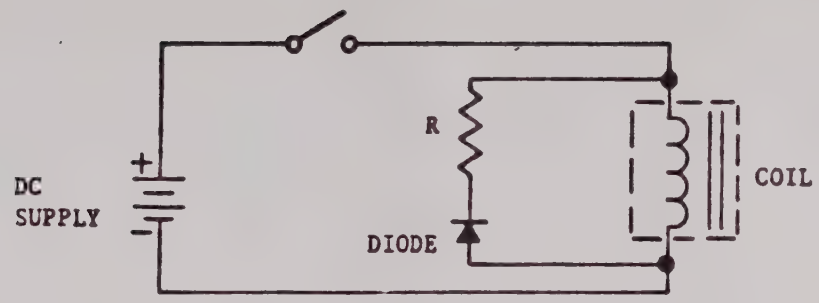


Figure 2 - Typical circuit for the suppression of DC coils

3. Contacts: All inductive coils store energy in the field created by the coil. If the coil is not suppressed by a MOV or R-C circuit in parallel with the coil, any contact or switch that interrupts the current to the coil will have a brief electrical arc across the contacts every time the contact is opened. It is this arc that generates noise interference that is picked up by electronic instruments.

The arc may be eliminated by the use of an R-C snubber in parallel across the contacts. For circuits up to 3 amperes and 300 VAC, a resistor of 47 ohms in series with a 0.1 uF @ 1000V capacitor is normally satisfactory. For voltages over 200 VAC, a MOV may also be paralleled across the contacts for additional suppression. See Figure 3 for typical circuit connections.

For contacts carrying current over 3 amperes, a rule-of-thumb would size the capacitor by specifying the number of microfarads equal to the number of amperes in the load current. The resistor value would be the same resistance as the load. In these cases, the important feature is to eliminate the visible arc on the contacts.

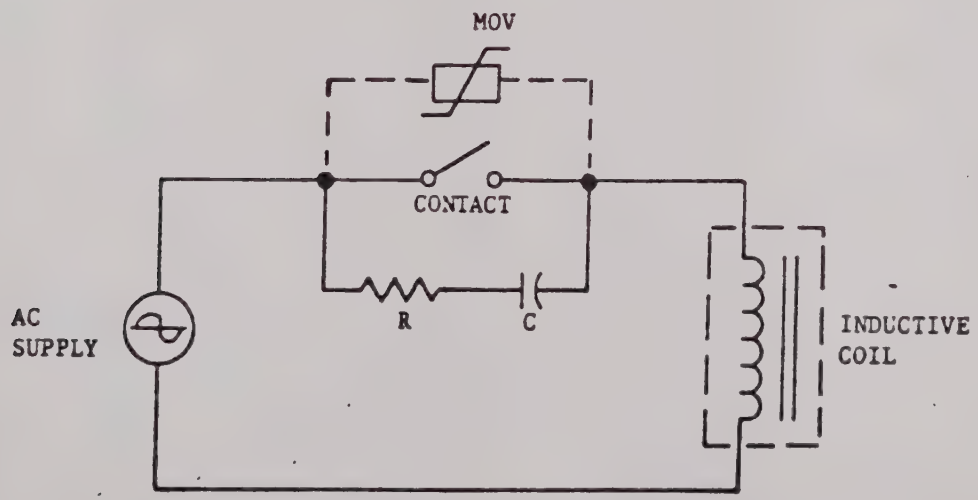
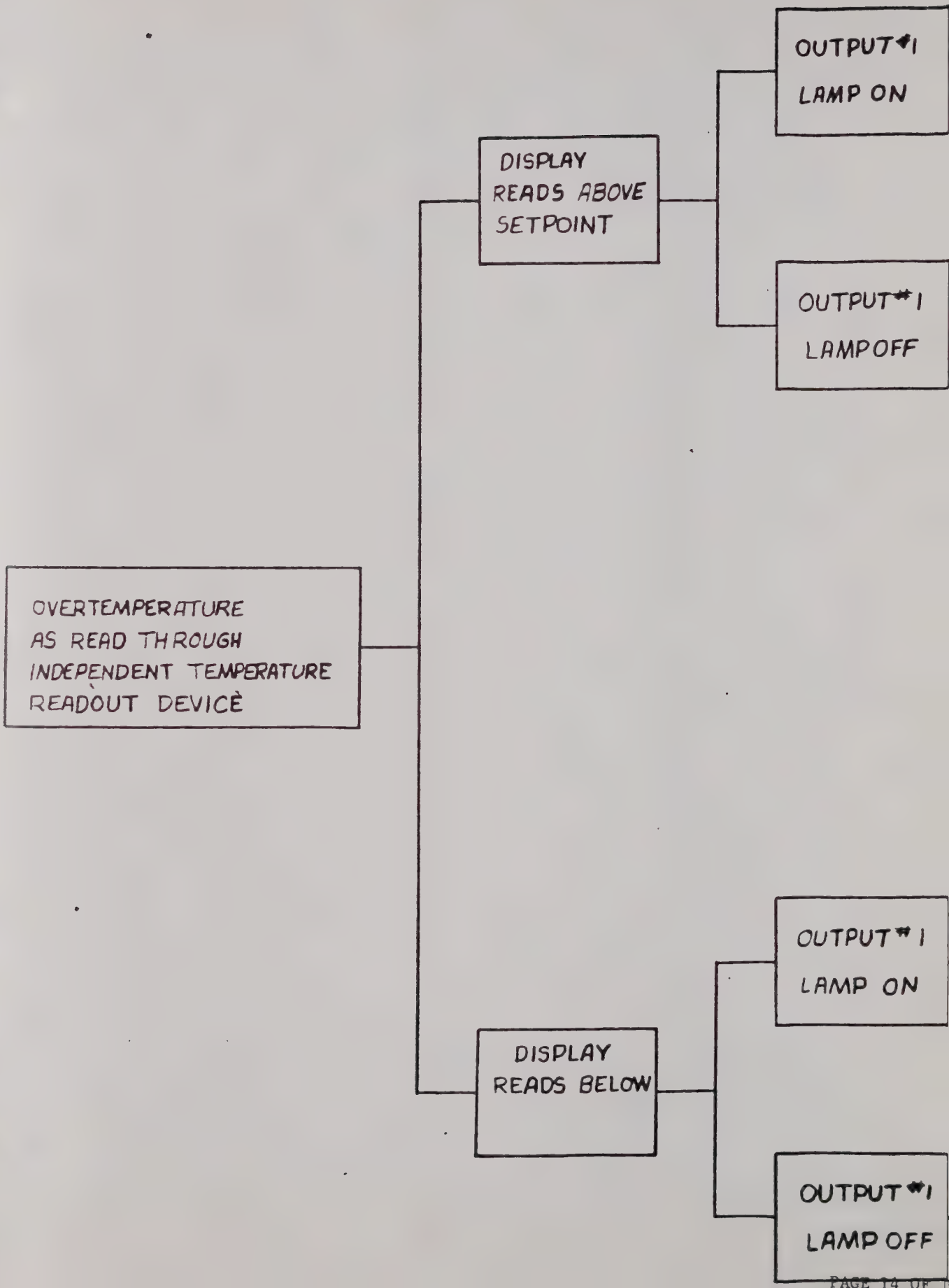
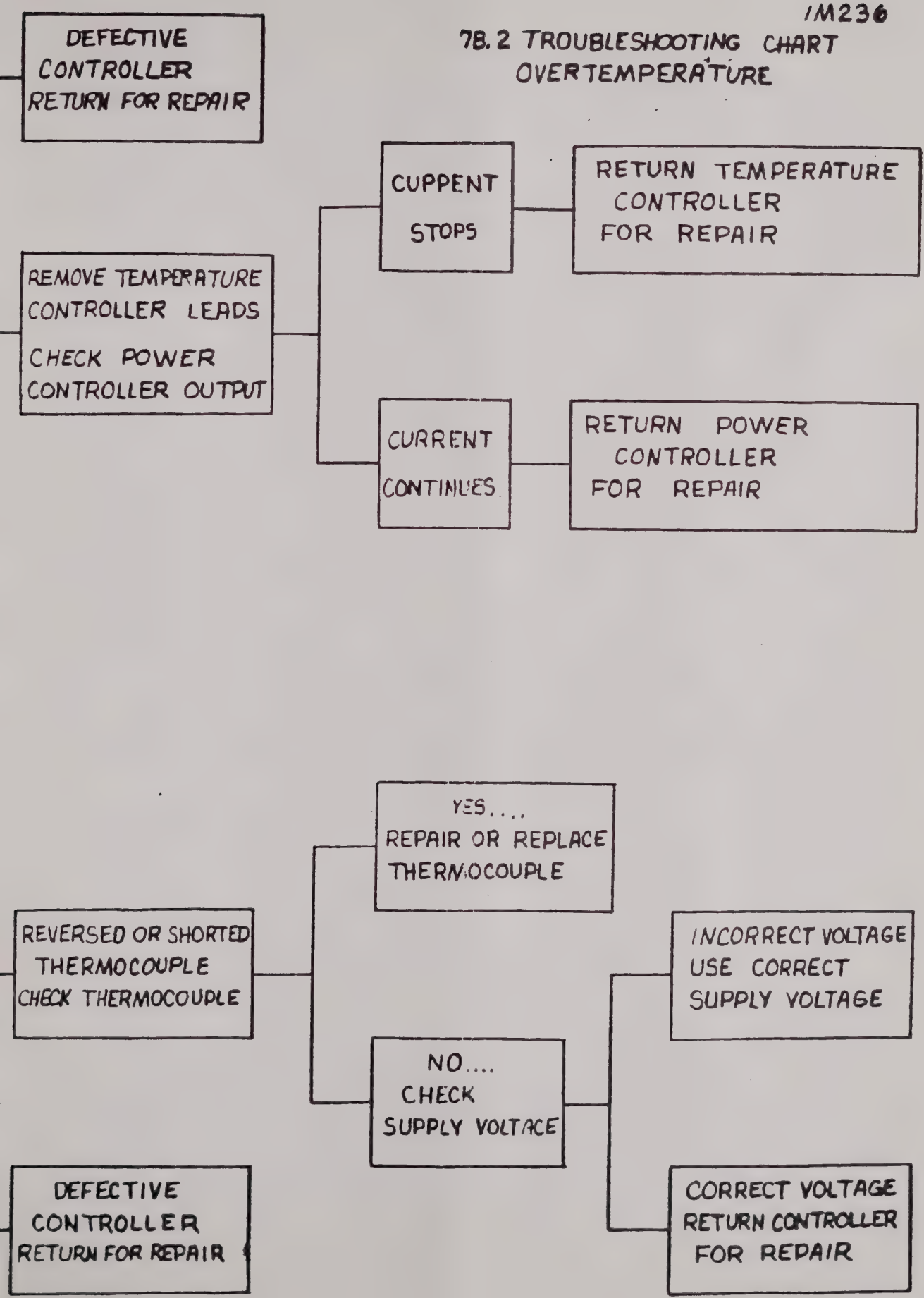
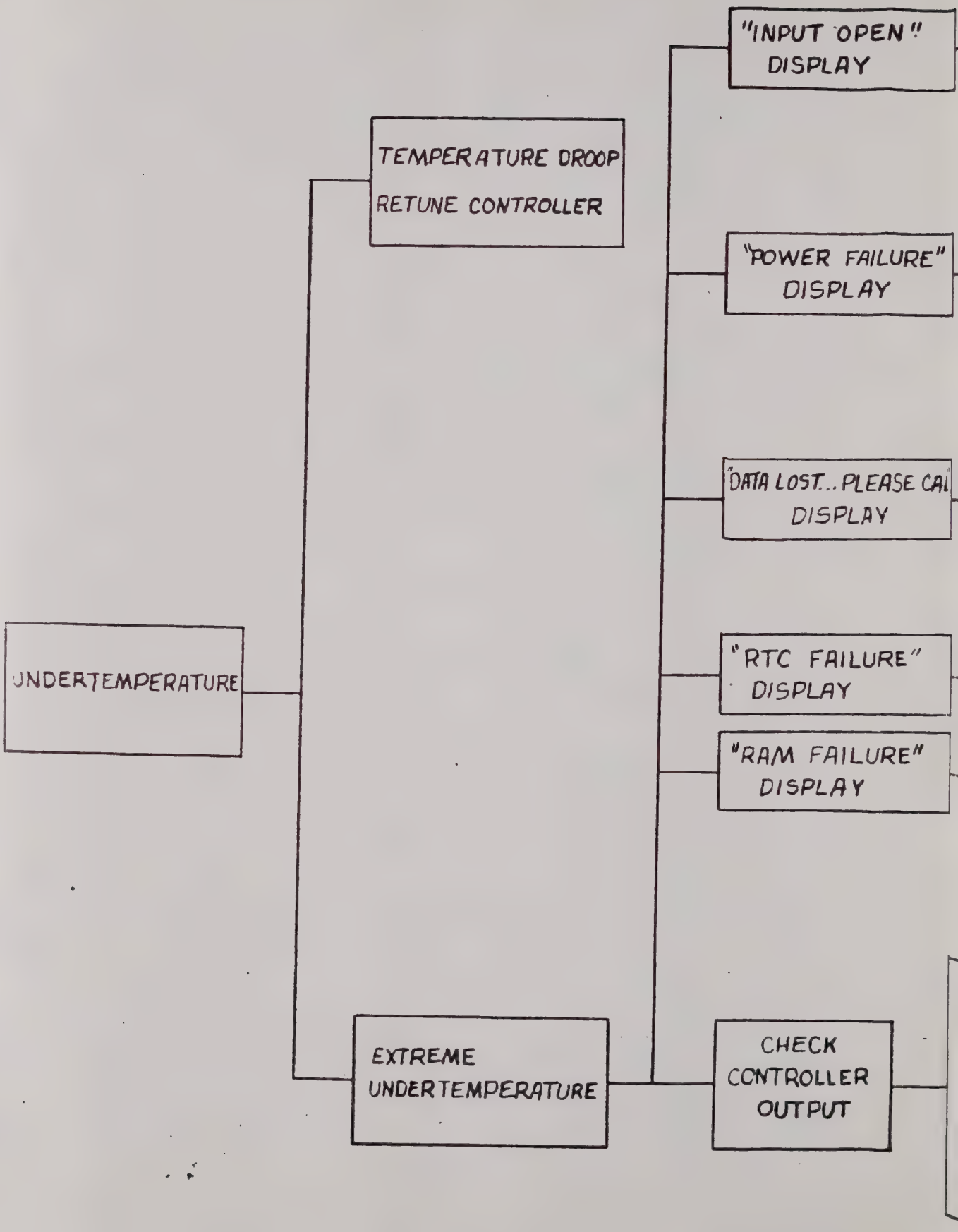


Figure 3 - Typical circuit for contact suppression


OVERTEMPERATURE AS READ THROUGH INDEPENDENT TEMPERATURE READOUT DEVICE
DISPLAY READS ABOVE SETPOINT
OUTPUT #1 LAMP ON
OUTPUT #1 LAMP OFF
DISPLAY READS BELOW
OUTPUT #1 LAMP ON
OUTPUT #1 LAMP OFF

78.2 TROUBLESHOOTING CHART OVERTEMPERATURE


DEFECTIVE CONTROLLER RETURN FOR REPAIR
CUPPENT STOPS
RETURN TEMPERATURE CONTROLLER FOR REPAIR
REMOVE TEMPERATURE CONTROLLER LEADS
CHECK POWER CONTROLLER OUTPUT
CURRENT CONTINUES
RETURN POWER CONTROLLER FOR REPAIR
YES.... REPAIR OR REPLACE THERMOCOUPLE
REVERSED OR SHORTED THERMOCOUPLE CHECK THERMOCOUPLE
INCORRECT VOLTAGE USE CORRECT SUPPLY VOLTAGE
NO.... CHECK SUPPLY VOLTAGE
DEFECTIVE CONTROLLER RETURN FOR REPAIR
CORRECT VOLTAGE RETURN CONTROLLER FOR REPAIR


"INPUT OPEN" DISPLAY
TEMPERATURE DROOP RETUNE CONTROLLER
"POWER FAILURE" DISPLAY
"DATA LOST... PLEASE CAL DISPLAY
UNDERTEMPERATURE
"RTC FAILURE" DISPLAY
"RAM FAILURE" DISPLAY
EXTREME UNDERTEMPERATURE
CHECK CONTROLLER OUTPUT

7B.3 TROUBLESHOOTING CHART
. UNDERTEMPERATURE

CHECK... TC AND EXTENSION WIRES FOR AN OPEN CIRCUIT
REPAIR OR REPLACE DEFECTIVE PARTS

CHECK...
THE AC VOLTAGE LEVEL
RESTORE TO CORRECT LEVEL

CONTROLLER MUST BE
CALIBRATED BY
QUALIFIED PERSONAL

SWITCH POWER OFF AND ON.
IF DISPLAYS REMAIN...
RETURN CONTROLLER FOR REPAIR.

CONTROLLER OUTPUT OK

CHECK POWER CONTROLLER OUTPUT

NO OUTPUT...
CHECK FUSES.... FUSES OK
CONTROLLER DEFECTIVE
RETURN FOR REPAIR

OUTPUT OK...
BAD HEATING ELEMENTS.
UNDERSIZED FURNACE.

CONTROLLER CALLS FOR OUTPUT
BUT NO OUTPUT
RETURN FOR REPAIR

ADDENDUM

DO NOT CONNECT ANY MEASURING OR CONTROL DEVICES TO THE CONTROL THERMOCOUPLE OTHER THAN THE PRINCIPLE TEMPERATURE CONTROLLER

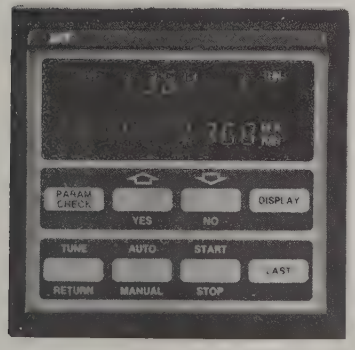
Instruments Division
A Mark IV Company

INSTALLATION AND OPERATION

PRICE $12.00

955-239
Rev.D
3087

MODEL 2010 and 2011 CONTROLLERS



The PμP™

INSTALLATION, TUNING, OPERATION
AND RECALIBRATION INSTRUCTIONS

AN INTRODUCTION

The introduction of microprocessors into panel mounted 1/4 DIN size controllers has resulted in control instruments with exceptional application flexibility. However, this broad capability can be very confusing to those not familiar with this new technology. This manual is written to take you step by step through the installation, set-up, operation and recalibration of this microprocessor based controller. Attention to this manual will help ensure a successful application.

The controller contains a unique alphanumeric display that actually shows key words as well as numerical information. Also on the front of the controller is an eight key operator interface. All operator communications are done through the front keypad. There are no internal jumpers, switches or pots to set or adjust. When you push the appropriate key, the controller will scroll through display routines to provide the information you need for complete tuning and proper operation as well as recalibration if required.

This instrument is a 3-Mode PID controller with ON/OFF, time proportional or analog output(s). It accepts one thermocouple, RTD, voltage or current input including a process input. The control output(s) can be solid state relay(s) or analog output(s). Two electromechanical Alarm/Timer relay(s) are also included.

Two special programs are available at all times. The RAMP & SOAK program can control up to 8 segments for profile control. Included in this program is ASSURED SOAK and REPEAT CYCLE selection. The MULTISETPOINT program allows the user to store up to 9 setpoints for operator recall on demand. Special displays prompt and inform the operator during programming and use of these special programs.

You can familiarize yourself with your controller prior to installation by attaching a properly protected (cover exposed terminals) AC power cord to terminals 6, 7 and 8 and a 100 ohm resistor between the input terminals F and H. The measurement on the display will be incorrect but all routines and displays will function properly. As you read this manual you can follow the functions right on the controller display. You cannot harm the controller by pushing any keys. Special care is required when in the calibration routine so as not to erase the factory set calibration. Follow the instructions carefully. Recalibration is covered in Section 6.

Model 2010 is a microprocessor based general purpose, 1/4 DIN size, single loop controller with unique display, control, tuning and operating features. They have START/STOP, AUTO/MANUAL, RAMP & SOAK and MULTISETPOINT functions.

Model 2011 Controllers are identical to Model 2010 except that they have digital COMMUNICATIONS capability. In all other aspects, the models are identical. All information in this manual applies to both models unless specifically excepted.

After reading the instructions, if you have any questions please contact our Sales Representative or the factory. We know that you will be pleased with the operation of this controller

WARNING: IN ANY CRITICAL APPLICATION WHERE FAILURE COULD CAUSE PRODUCT LOSS OR ENDANGER PERSONNEL, A SECOND REDUNDANT LIMIT CONTROLLER IS RECOMMENDED.

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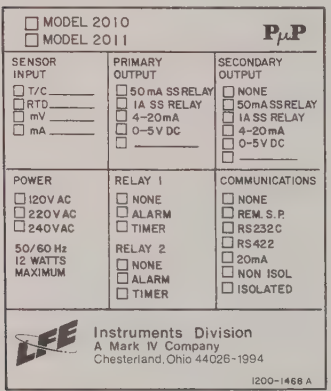
SECTION 1 - INSTALLATION

1.1 UNPACKING

Remove the unit from the shipping carton. Check to see that the unit has not been damaged in shipping. If equipment is damaged in transit, report any damage to and file a claim with the carrier.

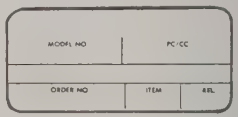
1.2 IDENTIFICATION

Refer to the case mounted top label on each unit for proper identification of supply voltage, Output(s), Alarm/Timer and Sensor type before proceeding with the wiring.

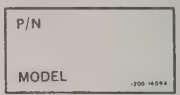


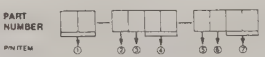
1.3 PART NUMBER

Each controller is assigned a ten-digit PART NUMBER at the factory or by the Modification Center that specifies its hardware and software configuration. The part number is shown on the production label mounted on top of the case immediately behind the front bezel.



The PART NUMBER is also located on a label on the mother board at the rear of the front bezel assembly. To read this label, the electronic assembly must be pulled out of the case. With the power off, squeeze the tabs on each side of the front bezel and pull the electronic assembly forward enough to expose the PN label. You do not have to remove the assembly from the case to read this label.





① Model

D0	2010	No communications
D1	2010	Remote Analog Setpoint
D2	2011	RS232C non-isolated
D3	2011	RS232C isolated
D4	2011	RS422 non-isolated
D5	2011	RS422 isolated
D6	2011	20 mA Current (isolated)

② Primary Output

0	NO PRIMARY
1	PRI HEAT SSR ON/OFF
2	PRI COOL SSR ON/OFF
3	PRI HEAT SSR PROP
4	PRI COOL SSR PROP
5	PRI HEAT 4-20 mA DC
6	PRI COOL 4-20 mA DC
7	PRI HEAT 0-5 V DC
8	PRI COOL 0-5 V DC

③ Secondary Output

0	NO SECONDARY
1	SEC HEAT SSR ON/OFF
2	SEC COOL SSR ON/OFF
4	SEC COOL SSR PROP
E	SEC COOL 4 20 mA DC
7	SEC COOL 0-5 V DC

④ Input

00	J thermocouple
01	K thermocouple
02	R thermocouple
03	S thermocouple
04	T thermocouple
05	N thermocouple
06	E thermocouple
07	B thermocouple
08	PLATINEL II T/C
09	N / N-18% Moly T/C
10	W5 Re / W26 Re T/C
11	W3 Re / W25 Re T/C
12	W / W26 Re T/C
20	1 * RTD 100 Ω PT
21	0.1 * RTD 100 Ω PT
40	0-5 volts DC
60	4-20 mA DC

⑤ Alarm/Timer 1

0	no alarm
1	HI process
2	LO process
3	HI deviation
4	LO deviation
5	ON Timer
6	OFF Timer

⑥ Alarm/Timer 2

0	no alarm
1	HI process
2	LO process
3	HI deviation
4	LO deviation
5	ON Timer
6	OFF Timer

⑦ Options

00	No options
XX	Any special. Factory assigns final numbers

1.4 MOUNTING

HAZARD: INSURE THAT ALL POWER AND MEASURING CIRCUITS ARE DISCONNECTED BEFORE INSTALLATION IS ATTEMPTED.

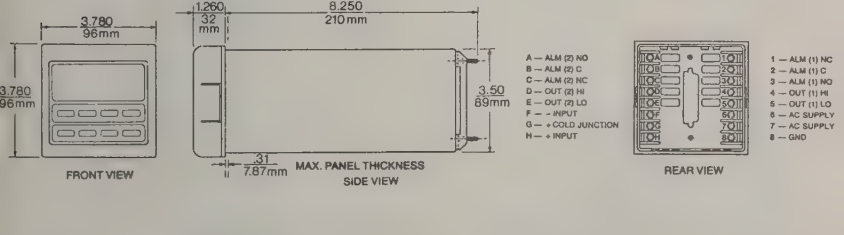
In the normal course of installation and operation, there is no reason to remove the electronic assembly from the case. If the electronic assembly is removed, SPECIAL PRECAUTIONS MUST BE TAKEN IN HANDLING THE CMOS INTEGRATED CIRCUITS TO PREVENT STATIC DISCHARGES FROM CAUSING DEVICE FAILURE.

The entire electronic assembly can be removed from the case for servicing without disturbing the rear terminal wiring by pressing in the tabs on each side of the bezel and carefully pulling the assembly out of the case. When digital communications is included, a ribbon cable connector must be pulled from the middle board before the assembly can be removed. When reinstalling the electronics assembly, make sure that the unit is inserted right side up and that all boards are firmly in their connectors.

The controller is designed for mounting in a control cabinet or rack where access to the rear terminals is enclosed and where supply and load wiring can be properly terminated and enclosed. Prepare a standard 1/4 DIN panel cutout of 3.620 inches by 3.620 inches (92 X 92 mm) and insert the instrument into the panel cutout. The U-shaped mounting bracket, supplied with each unit, is installed from the rear of the controller and held in place by two threaded studs mounted on the rear case. Tighten the bracket with the hardware supplied to insure a snug fit.

Overtightening may cause the rear of the case to bow. To prevent this, a washer of the panel thickness may be used over the stud between the case and the bracket.

The controller has been designed for panel mounting with natural convection cooling. When installing the unit, be sure that the case label and the rear vents are on the top side. Allow adequate clearance for proper air circulation.



PANEL CUTOUT 3.620 X 3.620 +.000/-.039 (92 X 92 mm)

NOTE: For panel mounting of two or more units, use a minimum horizontal spacing of 4.5 inches on center.

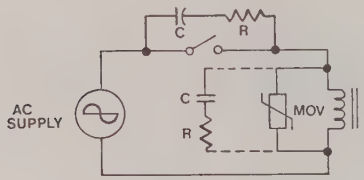
1.5 WIRING

Successful operation begins with proper installation. Good installation requires not only that good wiring practices be followed but also that reasonable protection be provided against external electrical influences that could interfere with controller operation. In addition all wiring must conform to applicable local and national codes. The controller should be wired with an external power disconnect and fuse.

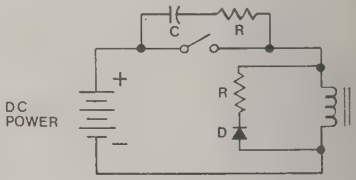
1.6 NOISE SUPPRESSION

The primary source of electrical interference (noise) that can impact any digital device is inductors most commonly found as coils and windings in solenoids, relays and transformers. It is important to suppress any potential for electrical noise at its source to ensure reliable controller operation. Specifically this means putting noise suppression devices across the terminals of all inductors in your system.

AC NOISE SUPPRESSOR



DC NOISE SUPPRESSOR



If you do not have the necessary components available, they may be purchased locally or in kit form from the factory.

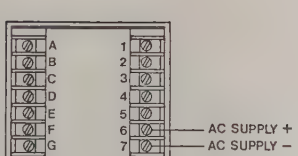
ITEM	MAX. AC	RATING	KIT
RC KIT	240 VAC	0.1uF/220 ohms	1821 - 100
MOV KIT	130 VAC	35 Joules	1821 - 98
MOV KIT	250 VAC	70 Joules	1821 - 99

When wiring to the controller, twisted pair with insulated shield is recommended for all signal leads. Make sure the shield is grounded ONLY at the controller - use the AC power ground terminal 8. Be sure to protect against ground loops in signal leads, shields and all other input and output wiring.

Low level signal leads and high level power cables must not be run in the same conduit or cable trays. Care when wiring means better system reliability.

1.7 AC SUPPLY WIRING

Connect the AC line power to the rear terminals as shown in this diagram. The unit is normally wired for 120 VAC operation. Refer to the label on the unit for proper AC supply voltage rating. Maximum input current at 120 VAC, 50/60 HZ is 115 mA AC. Other voltages are also available. Check and be sure.

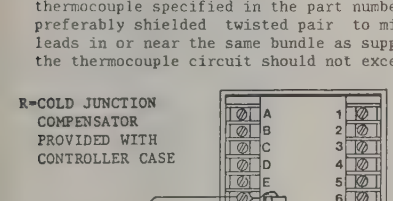


CAUTION: APPLYING HIGHER SUPPLY VOLTAGE TO A UNIT NOT RATED FOR THIS VOLTAGE WILL RESULT IN DAMAGE TO THE CONTROLLER.

1.8 THERMOCOUPLE INPUT

Connect the RED thermocouple wire or extension lead to the unit rear panel terminal "F" (T/C Return –). Connect the remaining thermocouple lead, differing in color depending upon the thermocouple type to the rear panel terminal "H" (+ T/C). No external connection is made to terminal "G".

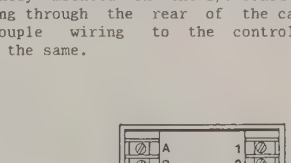
It is very important that the thermocouple extension leads be of the same type as the thermocouple specified in the part number, that all connections be clean and tight and preferably shielded twisted pair to minimize noise pick up. Never run signal input leads in or near the same bundle as supply or load lines. Maximum loop resistance of the thermocouple circuit should not exceed 100 ohms.



NOTE: Controllers manufactured starting in January 1986 have the compensating resistor permanently mounted on the I/O board and extending through the rear of the case. Thermocouple wiring to the controller remains the same.

1.9 RTD INPUT (100 OHM PLATINUM, 3850 ppm)

Connect the RTD sensor per the following figure for a 3 wire RTD input. If a two wire RTD is used, strap terminals F and G together and connect the RTD between terminals G and H.

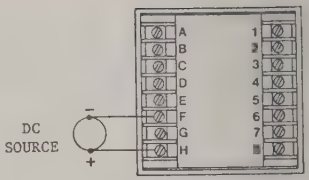


Note that the RTD leads can be extended with copper wire provided they are the same length and diameter and run in a common conduit. Maximum extension lead resistance shall not exceed 10 ohm.

The use of the shielded twisted pair is recommended to minimize noise pick up. Never run signal input leads in or near the same bundle as supply or load lines. For 2 wire RTD we recommend running 3 wires to the RTD and connecting the F and G wires together as near the RTD as possible.

1.10 PROCESS INPUTS - DC VOLTAGE OR CURRENT INPUT

Connect the +DC Input to terminal H and the -DC Input to terminal F (GND) for any current or voltage DC Input. The use of shielded twisted pair is recommended to minimize noise pick up. Never run signal input leads in the same bundle as supply or load lines.

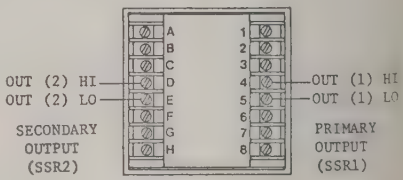


1.11 WIRING FOR SOLID STATE RELAY OUTPUT AND/OR SECONDARY OUTPUT

The PART NUMBER will specify which outputs are included in each unit. Since Solid State Relay and Analog Output use the same terminals only one type can be provided on each output. Output type is not changeable in the field.

The standard Solid State Relay output is 1 ampere opto-isolated triac output. An optional 50 mA triac output may be supplied for either or both SSR outputs (SSR1 and SSR2). Maximum voltage for SSR load is 240 VAC. See case label for type and rating of each output provided.

Current limiting fuses such as Bussman KAA or KAB series or Gould Shamut form 101 Amptrap (1 AMP) are recommended to protect the 1 AMP Solid State Relay.



APPLICATION NOTE: WHEN USING THE CONTROLLER SOLID STATE RELAY TO OPERATE AN EXTERNAL SOLID STATE RELAY OR SENSITIVE COIL RELAY TWO SITUATIONS MAY EXIST.

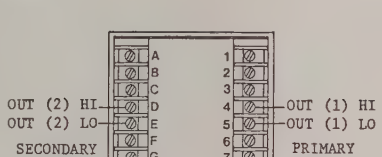
1. The leakage current in the 1 amp SSR may be sufficient to cause an external SSR to remain in the conducting state. To prevent this the 50 mA SSR option is recommended.

2. The low power draw of the external SSR may cause the controller SSR to turn OFF due to insufficient holding current. The solution to this is also to use the 50 mA SSR option. An alternate approach is to use a loading resistor across the external SSR or relay terminals to increase the current.

1.12 WIRING FOR ANALOG OUTPUT PRIMARY AND/OR SECONDARY (4/20 mADC OR 0/5VDC OUTPUT)

The part number will specify which outputs are included in each unit. Since the Solid State Relay and Analog Output use the same terminals only one type can be provided on each output. Output type is not changeable in the field.

NOTE: Maximum Load Resistance = 1K for 4/20 mA output.
Minimum Load Resistance = 1K for 0-5 VDC output.

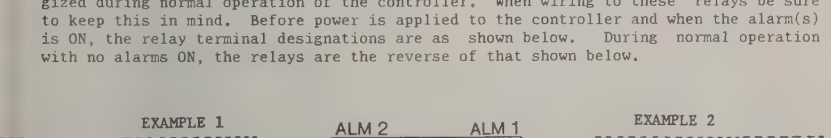


Standard controllers with analog output(s) have a common connection between the input and output circuits. Grounding both input and output may cause controller damage and loss of control. Isolated input or output are available if required.

1.13 ALARM/TIMER RELAY WIRING

Two independent electromechanical alarm relays rated 1 amp at 240 VAC resistive load are included. Both normally open (NO) and normally closed (NC) terminals are provided with one common return (C) for each relay.

Terminal designations normally refer to the de-energized state i.e. no power to the relays. To provide reliable alarm indication, the relays in this controller are energized during normal operation of the controller. When wiring to these relays be sure to keep this in mind. Before power is applied to the controller and when the alarm(s) is ON, the relay terminal designations are as shown below. During normal operation with no alarms ON, the relays are the reverse of that shown below.



Special care should be taken when wiring these relays to inductive devices such as coils and transformers. Noise suppressors as shown on the diagram are important to prevent electrical noise from being generated. See Section 1.6.

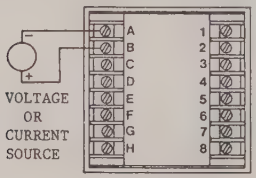
The Part Number specifies the type of Alarm/Timer relay action. Alarm/Timer relay action can be reconfigured if required without having to rewire the relay by following the instructions in Section 6.

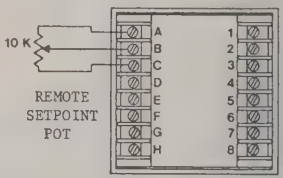
1.14 REMOTE SETPOINT INPUT

A controller with REMOTE SETPOINT input option provides for remote linear analog current or voltage control of the primary setpoint. Although the standard setpoint input is calibrated for 0 to 5 VDC, other voltages through 10 VDC or currents through 100 mADC may be supplied on special order. The remote input may be from an isolated stable current or voltage supply or, where the setpoint can be manually adjusted to the required value, it may use an internal controller supply with a remote potentiometer for a simplified source. All controllers supplied with remote setpoint input option have a part number whose second digit is a "1".

NOTE: Controllers with remote setpoint input option can not have an ALARM/TIMER 2 as these terminals are used for the remote setpoint input.

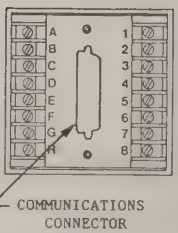
SPECIAL WIRING: The rear barrier terminal connections are changed as shown below. All other connections are as described in Section 1.





1.15 DIGITAL COMMUNICATIONS WIRING

Controllers with a digital communications option are provided with a special Type D (DB25) connector between the rear terminals. Wiring to this connector is discussed in detail in Section 5.



1.16 INITIAL POWER UP

After all connections have been made to the rear terminal connections and the correct wiring verified, power may be applied. The display should illuminate as soon as power is applied. If the multicolor vacuum fluorescent display does not illuminate immediately, disconnect the power and recheck the wiring. Allow at least 5 minutes for warm up before starting operation.

SECTION 2 - FUNCTIONS

2.1 MODES OF OPERATION

The controller can operate in one of two MODES i.e. the OPERATOR mode or the TUNE mode. This distinction is made because different displays appear on the front of the controller for each mode and you can perform different functions in each mode.

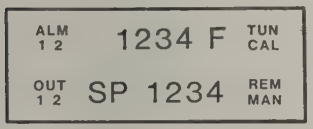
The OPERATOR mode is the normal mode of operation. It is explained in detail in Section 3. The TUNE mode is used for tuning and programming the controller prior to going on-line or during operation. Tuning is explained in detail in Section 4.

A third mode is used for calibration of the controller. This CAL mode is explained in detail in Section 6. The controller cannot operate while in the CAL mode.

Before putting the controller into operation please read the rest of this section, which explains the display and keypad functions.

2.2 DISPLAY

The front panel multicolor alphanumeric, vacuum fluorescent display provides all controller communications with the operator.



CONTROLLER DISPLAY

The central portion of the display is blue and contains sixteen alphanumeric characters in two rows of 8 characters each. This display shows key words to prompt and inform you during all phases of operation.

2.3 STATUS INDICATORS

Yellow MODE and STATUS indicators on the right side of the display illuminate to indicate specific controller status.

TUN - The yellow TUN indicator illuminates when the controller is in the TUNE mode.

CAL - The yellow CAL indicator illuminates when the controller is in the CALIBRATION mode. All control functions except the alarms are inactive while in the CAL mode.

REM (Steady) - The yellow REM indicator illuminates when the REMOTE SETPOINT option is included and in use. See Section 3.4. Also ON by computer command.

REM (Flashing)- The yellow REM indicator will flash when a Digital Communications option is included and in use. See Section 3.4.

MAN (Steady) - The yellow MAN indicator will illuminate when the controller outputs are under manual control.

MAN (Flashing)- The yellow MAN indicator will flash when the control outputs are OFF as a warning that no control action is taking place.

2.4 ALARM/TIMER INDICATORS

The two alarm indicators included in the upper left side of the display appear in red and illuminate "ALM" with either a 1 or 2 or both numbers when either or both alarms/timers are active. The part number specifies each relay action and type.

The two independent alarms, ALM1 and ALM2, consist of electromechanical relays with both NO and NC contacts on the rear terminals. The alarm circuitry is active at all times. The alarms continue to function even when the controller is in the TUNE mode or CAL mode. Timer relay(s), begin timing when the START key is pushed. They automatically reset and time resets to zero when the controller stops or the STOP key is pushed.

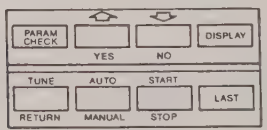
2.5 OUTPUT INDICATORS

The two output indicators included in the lower left side of the display appear in blue and illuminate the word "OUT" with either a 1 or 2 or both numbers when either or both outputs are ON. (1=Primary output and 2=Secondary output).

With ON/OFF and TPR (Time Proportional) control, the output indicator(s) will cycle ON and OFF as the outputs cycle ON and OFF.

With analog output control, the output indicator(s) will be ON when the output is ON and the measurement is outside the selected proportional band limits. When the measurement comes within the band limits the numerical indicator will flash with an ON/OFF ratio proportional to the analog output.

2.6 KEYPAD



CONTROLLER KEYPAD

The eight key membrane type keypad on the front panel is the operator interface. All control, tuning, and recalibration is performed using the keypad in conjunction with the display. There are no internal jumpers, switches or pots to set or adjust.

PARAM CHECK

The PARAM CHECK key advances the tune and calibration displayed information one step at a time allowing you to examine and change various system parameters.

YES

The UP arrow key, when pressed, will INCREASE the numeric value of the displayed parameter. Holding the key in will increase the rate of change of the parameter. Also use this key to answer YES to a displayed question "?".

NO

The DOWN arrow key, when pressed, will DECREASE the numeric value of the displayed parameter. Holding the key in will increase the rate of change of the parameter. Also use this key to answer NO to a displayed question.

DISPLAY

The DISPLAY key advances the OPERATOR loop displayed information one step at a time allowing you to examine and change various operating parameters.

TUNE
RETURN

The RETURN key returns the controller to the OPERATOR mode from any other mode. The TUNE key is used for security codes.

AUTO
MANUAL

The AUTO/MANUAL key transfers control of the outputs to and from automatic control. The MAN indicator is ON when the controller is in the manual mode. See detailed description in Section 3.3.

START
STOP

The START/STOP key turns the control action ON or OFF. This key is not a power switch. The MAN indicator will flash when the output(s) are turned off. See detailed description in Section 3.2.

LAST

The LAST key allows you to recall the previous display while in any mode.

2.7 ALARM/TIMER SELECTION

The Alarm/Timer relay circuitry has been designed such that the relay coil is energized during normal operation. This design reverses the normally open/normally closed contact nomenclature that is common in relay terminology. The advantage of this design is that in the event of power failure, the alarm relay(s) can provide an alarm indication. Terminal designations are given for the de-energized condition.

PROCESS alarm is an absolute value alarm that is independent of the setpoint and does not shift when setpoint is changed. It can be either HI or LO acting.

DEVIATION alarm is slaved to the controlling setpoint, and can be set as a plus or minus value above, equal to, or below the setpoint. A Deviation alarm shifts when the setpoint is changed. It can be HI or LO acting. Units are differential degrees shown on the display as DF or DC for temperature.

HI ACTING alarm activates when the measurement is equal to or above the alarm setpoint.

LO ACTING alarm activates when the measurement is equal to or below the alarm setpoint.

ON TIMER relay is OFF during the timing period and goes ON at the completion of the period. The ALM lamp will light at the end of the period.

OFF TIMER relay is ON during the timing period and goes OFF at the completion of the period. The ALM lamp will be ON during the period and goes OFF at the end of the period.

SECTION 3 - OPERATION

3.1 OPERATOR LOOP

The OPERATOR loop is available at all times allowing you to read all operating parameters. Since the OPERATOR mode is the standard operating mode, there is no OPERATOR indicator light. See Operator flow chart, Section 7.2. NOTE: Be sure to tune this controller prior to operation.

The DISPLAY key is used to advance the displays within this loop. The LAST key may be used to review the previous display at any time. Pushing the DISPLAY key will continuously repeat this loop.

The numerical value of any displayed number can be changed by pressing either the UP or DOWN arrow key. All possible displays are shown below. Your controller will only show displays appropriate to your application.

XX U SP XXX	This display shows the measurement value with units and the setpoint value. The setpoint can be changed using the arrow keys. Push the DISPLAY key to advance to the next display.
XX U OUT1 XX%	This display shows the measurement value and the primary output in percent power output. Manual control of the primary output is accomplished at this display. The controller must be ON for MANUAL control to function.
XX U OUT2 XX%	This display shows the measurement value and the secondary output in percent power output when a secondary output is provided. Manual control of the secondary output is accomplished at this display. The controller must be ON for MANUAL control to function.
AUX SP X DF	This display shows the auxiliary setpoint (AUX SP) when OUTPUT2 is an ON/OFF output. Units are differential (DX) between the primary and secondary setpoints.
TIMER? OVERRIDE	This display allows you to take manual control of TIMER1 or TIMER2 when they are included. Push the YES key to activate the next two displays when TIMER1 and/or TIMER2 are provided.
TIMER 1 ON/OFF TIMER 2 ON/OFF	Either or both of these displays allow you to turn TIMER relay(s) ON or OFF using the arrow keys when Timers are specified and enabled above. The ALM1 and ALM2 indicators will come ON when the TIMER relays are ON.
REMOTE ? SETPOINT	This display allows you to enable or disable the Remote Setpoint option using the YES/NO keys when this option is provided. The REM indicator will come ON when REMOTE SETPOINT is active.

ENABLE ?
COM LINK

This display allows you to enable or disable the Digital Communications option using the YES/NO keys when this option is provided. The REM indicator will flash when digital Communications is enabled. The Host can turn the REM indicator full ON.

3.2 STOP/START CONTROL

The STOP/START keys allows you to turn the control outputs ON and OFF. This is not a power switch. The controller electronic circuitry remains powered when the control outputs are turned OFF by this key.

The yellow MAN indicator will flash when the outputs are turned OFF.

3.3 AUTO/MANUAL CONTROL

The AUTO/MANUAL key allows you to take control and manually set the outputs from the keypad.

The OPERATOR loop includes two displays for manual control. These are OUT1 and OUT2 and show output as a % from 0 to 100% power.

With ON/OFF control the output is either fully ON or fully OFF. With Time Proportional control and analog control output, the output can be any value from 0 to 100% and can be adjusted to a particular value when in Manual control. To prevent severe process transients when switching between manual and automatic control, an internal program is provided that starts the automatic control at the manual setpoint. This means that Time Proportional and analog controllers will drive to the correct output power at a controlled rate when the PV is inside the proportional band. This action is called bumpless transfer and protects the process from severe transients during control transfer.

3.4 REMOTE SETPOINT OPTION

A second digit number "1" in the part number indicates that the controller has been specified and manufactured to accept an analog remote setpoint from an externally mounted potentiometer or remote voltage or current source.

REMOTE ?
SETPOINT

To enable this external input, advance the display in the OPERATOR loop until this display appears. See OPERATOR loop flow chart in Section 7.2.

Push the YES key to enable the remote setpoint input. The REM indicator will illuminate to confirm that control has been transferred from the internal setpoint to the external remote setpoint.

To disable this option, return to the REMOTE SETPOINT display and push the NO key.

3.5 DIGITAL COMMUNICATIONS

A second digit number 2 thru 6 in the part number indicates that the controller has been specified and manufactured with a Digital Communications option.

ENABLE ?
COM LINK

To enable Digital Communications, push the YES key at this display. See OPERATOR Flow Chart in Section 7.2.

To disable Digital Communications, push the NO key to this display.

The host cannot enable digital communications. This can only be accomplished by a key press on the front keypad of the controller. Even after communications is enabled, local control is still allowable.

During host-controlled operation, the front keypad remains active so that you can override the host and can take control if necessary.

The REM indicator light will flash when the communications is enabled. The REM indicator light will continue to flash until communications is disabled via the keypad. The host can also turn the REM indicator full on as part of the STATUS INPUT (PSW) command to inform you that the host is in control. Also included in the host command structure is manual control of the controller outputs).

3.6 RAMP & SOAK OPERATION

Ramp & Soak programming is done as part of the tuning procedure, see Section 4.6. To run a profile the controller must be in the OPERATOR mode. Press the START key to initiate Ramp & Soak control action. ALL RAMP & SOAK parameters previously entered in the TUNE loop may be viewed by the operator by sequentially pressing the PARAM CHECK key.

Pushing the DISPLAY key will scroll the following displays in the OPERATOR loop when a RAMP & SOAK program is active.

XXX UU
SPX XXXX

This display shows the measurement and the final setpoint required at the end of the current segment along with the segment number.

TMX LEFT
XX:XX

This display shows the TIME LEFT (TM) in the current segment of the profile along with the step number. The timer is a countdown timer. During an ASSURED SOAK hold, the timer will show 00:00.

CYC LEFT
XXX

This display shows the number of CYCLES of the ramp & Soak profile that remain to be executed when more than one repeat cycle has been programmed.

RAMP & SOAK setpoints and times can only be programmed in the TUNE mode. In the OPERATE mode, temporary changes may be made to the segment in progress by changing the TIME or SETPOINT with the UP/DOWN arrow keys, but the next time the RAMP & SOAK profile is used it will revert back to the values established in the TUNE mode.

When the controller has completed all cycles, it enters the STOP mode and waits for operator intervention. If another cycle (or series of cycles) is desired, the operator must again press the START key.

If the RAMP & SOAK is stopped in the middle of a run, the controller will start again at the beginning when restarted (Step one, Cycle one).

If power is lost during a RAMP & SOAK profile, the controller will continue from where it lost power when power is restored.

The clock will continue to run when the controller is put into MANUAL control during a run. When returned to AUTOmatic, the controller will continue at whatever point the clock indicates.

For host computer start-up of a RAMP & SOAK profile, see Section 5.

3.7 MULTISETPOINT OPERATION

XXXX UU
SPX XXX

Multisetpoint setpoints are programmed as part of the tuning procedure, see Section 4.7. To select a setpoint, the controller must be in the OPERATOR mode.

The first line of the display indicates the measurement. The second line of the display shows the setpoint number along with the setpoint value. Any setpoint can be called up. Push PARAM CHECK and LAST key (if necessary) to display the desired setpoint. Then press DISPLAY key to transfer the selected setpoint to the OPERATOR display. Control at the new setpoint begins immediately when the START key is pressed.

The setpoint value for any MULTISETPOINT can only be programmed while in the TUNE mode. A temporary change can be made to the selected setpoint using the arrow keys while in the OPERATOR loop, but the next time that setpoint is used its value will revert back to the value set while in the TUNE mode.

If MULTISETPOINT operation is no longer desired, the operator must deselect it in the TUNE mode. The controller then reverts back to whatever value was entered for setpoint 0. All the setpoints are saved and can be selected again at a later time.

3.8 PROFILE REVIEW

You can examine the settings for the profile from the OPERATOR loop by pressing the PARAM CHECK key. In this review, the time delay, the setpoint and time for each segment, cycles, etc. are sequentially displayed in the same order and form as they are set (see Section 5). Only the relevent displays will appear. The PARAM CHECK key will scroll through the profile settings and pressing the DISPLAY key returns you to the normal operator displays. The profile settings may not be changed while using the profile review feature; values for the current segment may be temporarily changed during one of the normal operator displays. To permanently change profile values, you must enter the TUNE loop (Section 4) and proceed as described in Section 5.

SECTION 4 - TUNING

4.1 CONTROLLER TUNING

This controller has been configured at the factory with input, output and alarm functions to meet your specific application. Arbitrary alarm and tuning values were used at the factory to allow complete controller checkout. It is necessary for you to TUNE this controller to your specific process or machine before going to automatic control.

In the tune program the PARAM CHECK key advances the displays. The LAST key may be used to review the previous display at any time.

This section provides complete details on all Tuning procedures.

4.2 THE TUNE LOOP

Access to the TUNE loop requires that a special key code be entered before any Tuning can be done. Press the keys TUNE-LAST-YES in sequence as shown in Figure 4-1 to enter the TUNE loop.

A yellow TUN indicator will illuminate on the display when the code is entered correctly. If the TUN indicator does not come ON, push the RETURN key and then push the code again. The PARAM CHECK key will advance the displays in the TUNE loop and the LAST key will back up the displays.

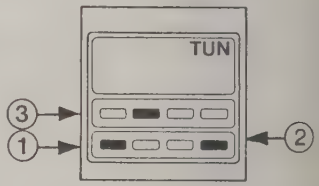


FIGURE 4-1

A flow chart of the TUNE loop is located in Section 7.3 that shows all possible displays in this loop. Your controller will only show those displays that are appropriate and necessary for your application.

ALARM 1	TIMER 1
XXXX UU	XXX:XX

OR

ALARM 2	TIMER 2
XXXX UU	XXX:XX

One or two of these displays will appear in sequence when alarms and/or timers have been included. Alarms can be process (display units) or deviation units (i.e., DF for Deviation Fahrenheit). Timers are set in units of HR:MIN or MIN:SEC up to 999:99 with the time units selected as part of the configuration calibration. Use the arrow keys to set in the desired alarm or time values. Push the PARAM CHECK key when the values are correct.

4.3 TUNING

For actual tuning, proceed by pushing the PARAM CHECK key.

TUNE ?
OUTPUTS

At this display, you must decide if you want to tune the controller or proceed to other functions. Tuning is required on all initial installations. If the NO key is pressed, the display goes to the "RAMP AND SOAK ?" display. If the YES key is pressed, the following displays appear in sequence.

DEAD BD1 X.XX%	For an ON/OFF primary output only, select a DEADBAND of 0.25, 0.50, or 1.00% of Span using the arrow keys. Factory preset at 0.25% of Span.
CYCTIME1 XX SEC	For a Time Proportional primary output only, set a cycle time (CYCTIMEO of 1 to 60 seconds using the arrow keys. Factory preset at 15 seconds.
PR BAND1 XXX%	Set a proportional band (PR BAND) of 1 to 200% of Span using the arrow keys. Factory preset at 5% of Span.
RESET 1 XX.XXR/M	Set a RESET of 00.00 to 20.00 Repeats per Minute using the arrow keys. Factory preset at 0.25 R/M. Setting RESET to 00.00 turns RESET OFF.
RATE 1 X.XX M	Set a RATE of 0.00 to 5.00 Minutes. Factory preset at 1.00 Minutes. Setting RATE to 0.00 turns RATE OFF.

When a secondary COOLING or ON/OFF HEATING output is included in your controller, a second set of displays follows for tuning of this output.

AUX DB XXX %	For an ON/OFF secondary output only, select an auxiliary deadband (AUX DB) of 0.25, 0.50 or 1.00% of Span using the arrow keys. Factory preset at 0.25% of Span.
CYCTIME2 XXX SEC	For Time Proportional secondary output only, set a cycle time (CYCTIME) of 1 to 60 seconds using the arrow keys. Factory preset at 15 seconds.
PR BAND2 XXX%	Set a proportional band 2(PR BAND) of 1 to 200% of Span using the arrow keys. Factory preset at 5% of Span.
RESET 2 XX.XXR/M	Set RESET 2 from 00.00 to 20.00 Repeats per Minute using the arrow keys. Factory preset at 0.25 R/M. Setting RESET 2 at 00.00 turns RESET 2 OFF.
RATE 2 X.XX M	Set RATE 2 from 0.00 to 5.00 Minutes using the arrow keys. Factory preset at 1.00 Minutes. Setting RATE 2 to 0.00 turns RATE OFF.

Output tuning is now complete for the controller. The TUNE loop continues with two special programs: RAMP & SOAK and MULTISETPOINT.

RAMP AND SOAK ?

The RAMP & SOAK (R&S) loop is always available in the controller program. A decision to select RAMP & SOAK must be made by the operator at this time by pushing either the YES or NO key.

A No decision will advance the program to the MULTISETPOINT display. A YES decision will allow the operator to use the RAMP & SOAK loop. Refer to Section 4.6 for details of the RAMP & SOAK loop.

MULTI ? SETPOINT

The MULTISETPOINT (MSP) loop is always available in the controller. A decision to select MULTISETPOINT must be made by the operator at this time by pushing either the YES or NO key. A No decision will advance the program to the END OF TUNE display. A YES decision will allow the operator to use the MULTISETPOINT program. Refer to Section 4.8 for details.

IMPORTANT: EITHER RAMP & SOAK OR MULTISETPOINT MAY BE SELECTED - BUT NOT BOTH. If one has been selected previously, it must be deselected in the TUNE loop before the other can be selected.

END OF TUNE

Tuning has now been completed. At this display you have several options. The LAST key will back up displays to review or change settings. The PARAM CHECK key will repeat the TUNE loop from the top. The RETURN key will exit the TUNE loop and return to the operator displays.

4.4 THE POINTERS

To simplify tuning of the controller, special logic called POINTERS has been included that allows you to jump back and forth between TUNE displays and OPERATOR displays quickly and efficiently.

To operate the pointers, the controller must be in TUNE mode - i.e., TUN indicator light must be "ON". When in the TUNE mode the DISPLAY key will call up and display the OPERATOR loop in programmed order. The PARAM CHECK key will call up and display the TUNE loop in programmed order.

It is possible to jump back and forth between the TUNE and OPERATOR loops by using the PARAM CHECK key when in the OPERATOR loop and the DISPLAY key when in the TUNE loop.

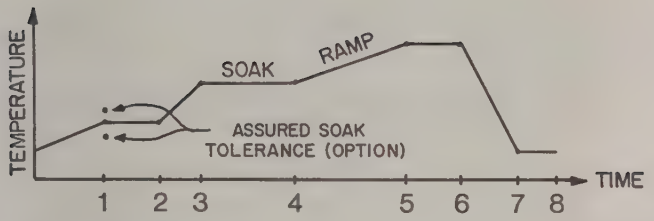
For example: In TUN mode, the display can be advanced to RESET 1 using the PARAM CHECK key. Then by pressing the DISPLAY key, the OPERATOR loop display for OUT 1 can be put on the display. The PARAM CHECK key displays RESET 1 for tuning. The DISPLAY key displays OUT 1 to observe control action resulting from the change in RESET 1. The operator can go back and forth between these two displays at the touch of a key for quick and efficient tuning.

4.5 RAMP & SOAK PROGRAM

The RAMP & SOAK program stored in permanent memory allows you to establish RAMP & SOAK control for a specific application. The RAMP & SOAK loop is fully compatible with all control modes and output actions of the controller. The program can have up to eight distinct segments with ramp times of up to 100 hours and soak times of up to 100 hours, each of which are settable to one minute resolution (one second resolution optional).

The selected ramp time together with the starting and ending setpoint determine the internal setpoint rate of change for the ramp action. A soak cycle is selected by setting in the same ending temperature as the starting temperature. The controller will provide output control action to maintain the setpoint temperature during soak.

RAMP & SOAK profiles are established in the TUNE mode. RAMP & SOAK operations are run in the OPERATOR mode.



4.6 CREATING A RAMP & SOAK PROFILE

The setpoints for a RAMP & SOAK profile are set in the TUNE mode. The PARAM CHECK key is used to step through the entire profile and the arrow keys to set in the values. The LAST key can be used to back up within the loop to change or check previous settings. See RAMP & SOAK flowchart 7.3A.

There are eight segments starting with SET PT Ø through SET PT 8. Any lesser number of segments can be used. Setting a segment time to 00:00 will terminate the RAMP & SOAK program at that segment.

To program a Ramp & Soak profile start in the TUNE mode with the TUN indicator ON. Advance the program with the PARAM CHECK key to the RAMP & SOAK display.

RAMP AND SOAK ?	Answer YES to this displayed question. This is the starting point for RAMP & SOAK programming. RAMP & SOAK will now remain active until you return to this display and push the NO key.
SET PTØ XXX XX	Set the initial setpoint for your profile. The controller will, when started, provide automatic control action to bring the measurement to this initial setpoint. Then push the PARAM CHECK key.
TIME 1 XX:XX	This is the first time interval between setpoint Ø and setpoint 1 for the RAMP & SOAK profile. Settings up to 99 hours and 59 minutes or 99minutes and 59 seconds (99:59) can be programmed using the arrow keys. The Hour/Min. or Min/Sec. decision is made as part of calibration. See Section 6.7.
SET PT 1 XXX XX	SET PT 1 is the endpoint for the first step of the RAMP & SOAK loop. It is set equal to SET PT Ø for a soak interval or different from SET PT Ø for a ramp interval.

Seven more sets of time and setpoint displays will appear in numerical sequence when the PARAM CHECK key is pushed. The numerical values are set using the arrow keys. If any time interval is set at 00:00, the RAMP & SOAK profile ends at that segment and the display proceeds as follows:

CYCLES XXX	This display allows you to instruct the controller to automatically repeat the RAMP & SOAK program for up to 254 cycles or it can be cycled continuously (CYCLES CONT) if set to one count above 254 cycles.

ASSURED SOAK ?

ASSURED SOAK, when acknowledged YES, holds the timer until the measured temperature is within a specified tolerance of the setpoint at the start of each segment. The timer will show 00:00 when holding during ASSURED SOAK operation.

Without ASSURED SOAK, the RAMP & SOAK program will continue based on time even if the process system does not allow the process variable to reach the specified setpoint during the programmed time.

When ASSURED SOAK has been selected, RAMP & SOAK control will not begin until the measurement is within the soak tolerance. A RAMP & SOAK profile with ASSURED SOAK may take longer than the sum of all the segment times.

SOAK TOL XXX DU

This display only appears when ASSURED SOAK is requested. The soak tolerance (TOL) is specified as differential units form the primary setpoint. Soak tolerance can be 1 to 200 units set in using the arrow keys. Once the process is within this tolerance, the timer starts and will continue even if the measurement later deviates outside of the tolerance during a RAMP or SOAK interval. The ASSURED SOAK check is made only at the end of each Time interval.

END OF TUNE

This display is the final step in the RAMP & SOAK profile. Pushing the RETURN key locks the RAMP & SOAK profile into memory and also turns OFF the outputs. (MAN indicator displays a blinking condition.)

If RAMP & SOAK operation is no longer desired, the operator must deselect it in the TUNE loop, i.e., answer NO at RAMP & SOAK display. The controller then reverts back to whatever value is set for setpoint number Ø. The RAMP & SOAK parameters remain saved and can be selected again at a later time.

Alternate modes of operation are possible. If another procedure is required, contact the factory.

4.7 MULTISETPOINT PROGRAM

The MULTISETPOINT Program stored in permanent memory allows you to establish up to nine setpoints for recall at a later time. This loop is fully compatible with all the control and action modes of the controller. Either RAMP & SOAK or MULTISETPOINT program may be selected, but not both. If one has been selected previously, it must be deselected in the TUNE loop before the other can be selected.

The setpoints for a MULTISETPOINT loop are set in the TUNE mode using the PARAM CHECK key to step through the nine setpoints and the arrow keys to set in the numerical values. At "END OF TUNE" push the RETURN key to lock in all setpoints and to put the controller in the stop mode.

4.8 CREATING A MULTISETPOINT MENU

Up to nine setpoints can be set from Setpoint Ø to Setpoint 8. See MULTISETPOINT flowchart, Section 7.3A. Ignore unneeded setpoints. To establish a MULTISETPOINT menu, call up the TUNE mode - i.e., TUN indicator "ON" and then advance the tune program using the PARAM CHECK key until "RAMP & SOAK" is displayed.

RAMP AND SOAK ?	To select MULTISETPOINT operation, you must first answer NO to this question if it has previously been selected. This is the "deselect" step.
MULTI ? SETPOINT	To create a MULTISETPOINT menu, you must answer YES to this displayed question. This is the start of the MULTISETPOINT loop.
SET PT Ø XXX UU	This is Setpoint Ø. Set in the desired setpoint value using the arrow keys.

Eight more setpoint displays will appear in numerical sequence when the PARAM CHECK key is pushed. Set in the desired setpoint values using the arrow keys. Ignore unneeded setpoints, but be sure to advance to "END OF TUNE".

END OF TUNE	This display is the final step in the MULTISETPOINT loop. Pushing the RETURN key locks the SETPOINT data into memory and turns off the outputs. (MAN indicator flashing.)

You can then call up the desired setpoint by number rather than by numerical value while in the OPERATOR mode, see Section 3.7.

4.9 TUNING A THREE MODE (PID) CONTROLLER

The controller is capable of exceptional control stability when properly tuned and used. You can achieve the fastest response time and smallest overshoot by following these instructions carefully. The information for tuning this three mode controller may be different from other controller tuning procedures.

START UP: After the controller is installed and wired:

a) Apply power to controller
b) Disable the control outputs by pressing the STOP key. The "MAN" indicator will flash.
c) Enter the TUNE loop by pushing TUNE-LAST-YES keys in sequence. (The TUN indicator will illuminate.
d) Press PARAM CHECK key to advance the TUNE program to "TUNE OUTPUTS".
e) Press YES key. For time proportional primary output, CYCTIME1 will appear. Enter the following value:

CYCTIME1----------5 SEC (A smaller cycle time may be required for systems with an extremely fast response time.)

f) Press PARAM CHECK key and sequentially enter the following values:

PR BAND 1 ----------5% (PB)
RESET 1 ----------0 R/M (Turns off Reset Function)
RATE 1 ----------0 MIN (Turns off Rate Function)

Also set all Secondary tuning values to 0.

NOTE: The procedure used in this section is for a "HEATING" output. A similar procedure may be used for a COOLING output.

TUNING THE OUTPUTS FOR HEATING CONTROL

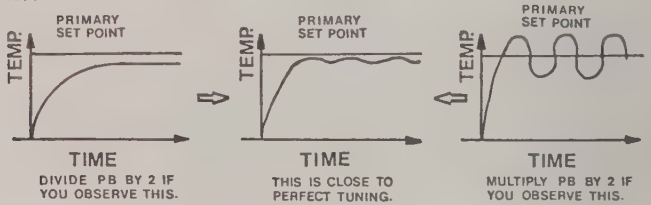
The tuning procedure is easier to follow if you use a recorder to monitor the process variable.

1) Press the DISPLAY key (see THE POINTERS - Section 4.4) so that the measurement appears on the screen. It is not necessary to return to OPERATOR mode while tuning the controller. OFF.

   Press Start key to enable the OUTPUTS(s) and start the process. The "MAN" indicator must be OFF.

2) The process should be run at a setpoint that will allow the temperature to stabilize with heat input required.

3) With RATE and RESET turned OFF, the temperature will stabilize with a steady deviation, or droop, between the setpoint and the actual temperature. Carefully note whether or not there are regular cycles or oscillations in this temperature by observing the measurement on the display. (An oscillation may be as long as 30 minutes).

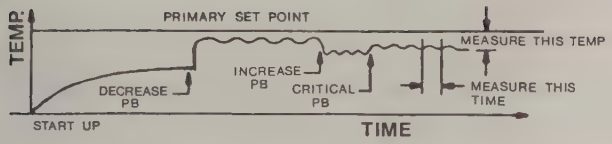


4) If there are no regular oscillations in the temperature, divide the PB by 2. Allow the process to stabilize and check for temperature oscillations. If there are still no oscillations, divide the PB by 2 again. Repeat until cycles or oscillations are obtained. Proceed to step 5.

   If oscillations are observed immediately, multiply the PB by 2. Observe the resulting temperature for several minutes. If the oscillations continue, keep doubling the PB until the oscillations stop.

5) The PB is now very near its "CRITICAL" setting. Carefully increase or decrease the PB setting until cycles or oscillations JUST appear in the temperature recording.

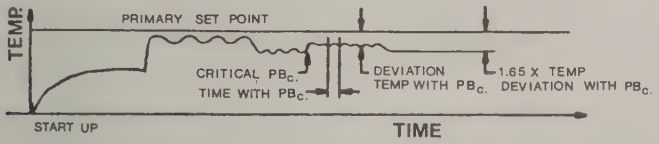
   If no oscillations occur in the process temperature even at the minimum PB setting of 1%, skip steps 6 thru 14 below and proceed to the Section: "TUNING PROCEDURE WHEN NO OSCILLATIONS ARE OBSERVED".



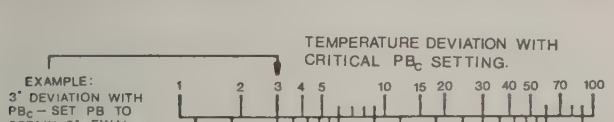
6) Read the steady-state deviation, or droop, between setpoint and actual temperature with the "CRITICAL" PB setting you have achieved. (Because the temperature is cycling a bit, use the average temperature).

7) Measure the oscillation time, in minutes, between neighboring peaks or valleys. This is most easily accomplished with a chart recorder: but a measurement can be read at 1 minute intervals to obtain the timing.

8) Now, increase the PB setting until the temperature deviation, or droop, increases 65%.



The desired final temperature deviation can be calculated by multiplying the initial temperature deviation achieved with the "CRITICAL" PB setting by 1.65 or by use of the convenient Nomogram I below. Try several trial- and-error settings of the PB control until the desired final temperature deviation is achieved.


TEMPERATURE DEVIATION WITH CRITICAL PB_c SETTING.
EXAMPLE:
3° DEVIATION WITH PB_c – SET PB TO OBTAIN 5° FINAL DEVIATION.
1 2 3 4 5 10 15 20 30 40 50 70 100
2 3 5 10 15 20 30 40 50 100 150
FINAL TEMPERATURE DEVIATION = 1.65 DEVIATION WITH CRITICAL PB_c SETTING.

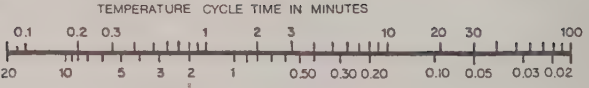
NOMOGRAM I

9) You have now completed all the necessary measurements to obtain optimum performance from the controller. Only two more adjustments are required; RATE and RESET.

10) Using the oscillation time measured in Step 7, calculate the value for RESET in repeats per minutes as follows:

$$\text{RESET} = \frac{8}{5} \times \frac{1}{To} \quad ; \text{ Where To = Oscillation Time in Minutes.}$$

Or use Nomogram II below:


TEMPERATURE CYCLE TIME IN MINUTES
0.1 0.2 0.3 1 2 3 10 20 30 100
20 10 5 3 2 1 0.50 0.30 0.20 0.10 0.05 0.03 0.02
CORRECT RESET SETTING IN REPEATS PER MINUTE

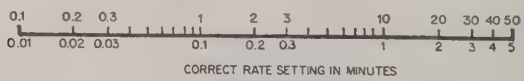
NOMOGRAM II

Enter this value for RESET 1.

11) Again using the oscillation time measured in Step 7, calculate the value for RATE in minutes as follows:

$$\text{RATE} = \frac{To}{10} \quad : \text{ Where To = Oscillation Time in Minutes}$$

Or use Nomogram III below and enter this value for RATE 1.



NOMOGRAM III

12) If overshoot occurred, it can be eliminated by decreasing the RESET time. When changes are made in the RESET value, a corresponding change should also be made in the RATE adjustment so that the RATE value is equal to:

$$\text{RATE} = \frac{1}{6 \text{ X Reset Value}}$$

i.e., If reset = 2 R/M then Rate equals 0.08 Min.

13) Several setpoint changes and consequent RESET and RATE time adjustments may be required to obtain the proper balance between "RESPONSE TIME" to a system upset and "SETTLING TIME". In general, fast response is accompanied by larger overshoot and consequently shorter time for the process to "SETTLE OUT". Conversely, it the response is slower, the process tends to slide into the final value with little or no overshoot. The requirements of the system dictate which action is desired.

14) When satisfactory tuning has been achieved, the cycle time should be increased to save contactor life (applies to units with time proportioning outputs only (TPR). Increase the cycle time as much as possible without causing oscillations in the measurement due to load cycling.

TUNING PROCEDURE WHEN NO OSCILLATIONS ARE OBSERVED

1) Measure the steady-state deviation, or droop, between setpoint and actual temperature with minimum PB setting.

2) Increase the PB setting until the temperature deviation (droop) increases 65%. Nomogram I in previous step 8 provides a convenient method calculating the desired final temperature deviation.

3) Set the RESET 1 to a high value (10 R/M). Set the RATE 1 to a corresponding value (.02 MIN). At this point, the measurement should stabilize at the setpoint temperature due to reset action.

4) Since we were not able to determine a "CRITICAL" oscillations time, the optimum settings of the RESET and RATE adjustments must be determined by trial and error. After the temperature has stabilized at setpoint, increase the setpoint temperature setting by 10 degrees. Observe the overshoot associated with the rise in actual temperature. Then return the setpoint setting to its original value and again observe the undershoot associated with the actual temperature change.

4.10 TUNING THE PRIMARY FOR COOLING CONTROL

The same procedure is used as defined for heating. The process should be run at a setpoint that requires cooling control before the temperature will stabilize.

4.11 SIMPLIFIED TUNING PROCEDURE FOR PID CONTROLLERS

The following procedure is a graphical technique of analyzing a process response curve to a step input. It is much easier with a strip chart recorder reading the process variable (PV). Refer to the diagram below.

1. Starting from a cold start (PV at ambient), apply full power to the process without the controller in the loop i.e. open loop controller in MANUAL mode. Record this starting time.

2. After some delay (for heat to reach the sensor), the PV will start to rise. After more of a delay, the PV will reach a maximum rate of change (slope). Record the time that this maximum slope occurs, and the PV at which it occurs. Record the maximum slope in degrees per minute. Turn OFF system power.

3. Draw a line from the point of maximum slope back to the ambient temperature axis to obtain the lumped system time delay Td (see example below). The time delay may also be obtained by the equation:

   Td = time to max. slope - (PV at max. slope - ambient)/max. slope

4. Apply the following equations to yield the PID parameters:

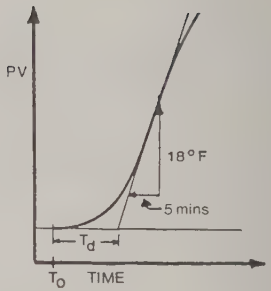
   Pr. Band = Td X max. slope X 100/Span = % of Span
   Reset = 0.4/Td = resets/minute
   Rate = 0.4 X Td = minutes

5. Bring the process to setpoint with the controller in the loop and observe response. If the response has too much overshoot, or is oscillating, then the PID parameters can be changed (slightly, one at a time, and observing process response) in the following directions:

   Widen the Proportional Band, lower the Reset value, and increase the Rate value.

Example:

The chart recording to the right was obtained by applying full power to an oven. The chart scales are 10°F/cm, and 5 min/cm. The controller range is 100-600°F, for a span of 500°F.



Max. slope = 18°F/5 min
= 3.6°F/min

Time delay = Td = approximately 7 min
PR Band = 7 min X 3.6°F/min
X 100/500°F = 5%

Reset = 0.4/7 min = 0.06 Resets/min
Rate = 0.4 X 7 min = 2.8 min

SECTION 5 - DIGITAL COMMUNICATIONS

5.1 COMMUNICATIONS IDENTIFICATION

The specific type of digital communications circuitry provided in the controller is indicated by the second digit of the ten digit part number.

MODEL 2011	TYPE
D0 -	No digital communications
D1 -	No digital communications
D2 -	RS232C non-isolated
D3 -	RS232C isolated
D4 -	RS422 non-isolated
D5 -	RS422 isolated
D6 -	20mA Current loop isolated

The communications circuitry is located on the middle circuit board of the electronic assembly. This board plugs into the front bezel assembly and connects to the rear "D" connector by means of a flexible flat ribbon cable that plugs into the bottom edge of the communications circuit board.

5.2 COMMUNICATIONS CONNECTOR

The "D" Type (DB25S) 25-PIN digital communications connector located at the rear of the controller is a standard Electronic Industries Associates (EIA) interface for RS232C. RS422 and 20 mA current loop use the same connector.

Wiring to the controller is identical to that for any Data Terminal. The following table identifies each connector pin by function. Sections 5.5- 5.7 specify the specific wiring for the three available interfaces.

5.3 CONNECTOR PIN DESIGNATIONS

PIN	MNEMONIC	SIGNAL	DESCRIPTION
1	GWG	Protective Ground	In the RS232C environment this line provides a ground connection between devices. Although not required, may also be used for RS422 and 20 mA current loop configurations for the same purpose.
2	TX	Send Data	Transmits data within RS232C voltage levels (+12V and -12V) or RS422 voltage levels (0 and 5V differential). Also used by the 20 mA current as 20 mA input (user supplied) for the transmit loop.
3	RX	Receive Data	Accepts data within RS232C or RS422 voltage levels or used by the 20 mA current loop as 20 mA input (user supplied) for the receive loop.
4	RTS	Request to Send	This line is normally held inactive by the controller until a message is ready to be sent. Then the line is switched active and the controller waits for the clear to send.

PIN	MNEMONIC	SIGNAL	DESCRIPTION
5	CTS	Clear to Send	This line must be made active by the host in order for the controller to send data unless handshake lines are inactive (see switch settings in Section 5.8).
6	DSR	Data Set Ready	Since the controller is a respond only device and does not initiate correspondence, the controller assumes that the host is ready to receive if the clear to send line is active, and does not monitor this line.
7	SG	Signal Ground	This line provides a common signal connection for the RS232C environment. It is also used as a ground reference for the power supplied by user for isolated configurations.
8	DTR-	Data Terminal Ready Return	Return line for Data Terminal Ready signal (PIN 20) used with RS422 with handshake only.
9	+V	Positive Voltage	User must supply +12 VDC on this PIN if using RS232 isolated or +5 VDC if using RS422 isolated configuration. No connection otherwise.
10	-V	Negative Voltage	User must supply -12 VDC on this PIN if using RS232C isolated configuration. No connection otherwise.
11	CTS-	CTS Return	Return line for Clear to Send signal (PIN 5) used with RS422 with handshake only.
14	TX-	Send Data Return	Return line for Send Data signal (PIN 2) used with RS422. Also 20 mA current loop return line for transmit loop.
16	RTS-	Request to Send Return	Return line for Request to Send signal (PIN 5) used only with RS422 with handshake.
18	RX-	Receive Data Return	Return line for Receive Data signal (PIN 3) used with RS422 or 20 mA current loop on receive loop. Internally tied to Signal Ground (PIN 7) for RS232C operations.
20	DTR	Data Terminal Ready	When handshake lines are used, this line is always active telling the host to send data at any time. This line is in an undetermined state when handshake is not used.
25	DSR-	Data Set Read Return	Return line used for Data Set Ready signal (PIN 6) used with RS422 with handshake only.

NOTES:

1. All signals are named with respect to the originating unit.

2. All undesignated PINS are to be left open.

3. User must supply +12 VDC @ 125 mA on Pin 9, -12 VDC @ 50 mA on Pin 10 referenced to ground on PIN 7 for isolated RS232C operation. For isolated RS422 operation the user must supply +5 VDC @ 150 mA on PIN 9 referenced to ground on PIN 7.

5.4 HANDSHAKE OPTION

The controller digital communications includes provision for the full handshake operation for use in RS232C and RS422 interfaces. To enable handshake for these interfaces, set the S2 switch number 4 "ON" (See Section 5.8). Four signal leads are used.

PIN 4	RTS	Request to Send
PIN 5	CTS	Clear to Send
PIN 6	DSR	DATA Set Ready
PIN 20	DTR	Data Terminal Ready

The RS422 also requires return lines.

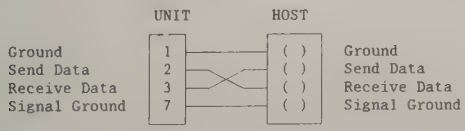
PIN 16	RTS	Request to Send Return
PIN 11	CTS	Clear to Send Return
PIN 25	DSR	Data Set Ready Return
PIN 8	DTR	Data Terminal Ready Return

The interface diagrams (Sections 5.5-5.7) shown are suggestions ONLY. There are several alternate wiring configurations depending on the host. It is essential to compare the host or modem requirements with the PIN designations before connecting the system.

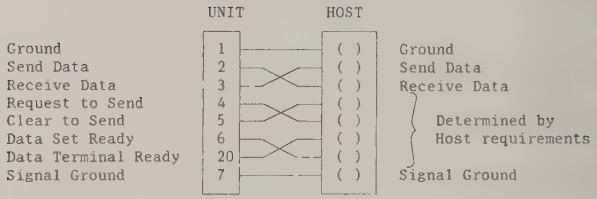
If handshake is not required or if these signals are not compatible with the host computer, the S2 switch number 4 MUST be "OFF". Handshaking cannot be used for any 20 mA current loop interface or for drop line RS422 configurations.

5.5 RS232C INTERFACE

RS232C HALF/FULL DUPLEX
WITHOUT HANDSHAKE

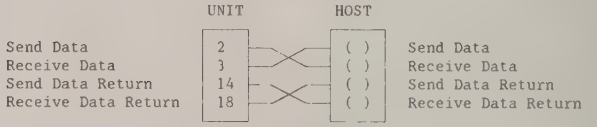


232C HALF/FULL DUPLEX
WITH HANDSHAKE

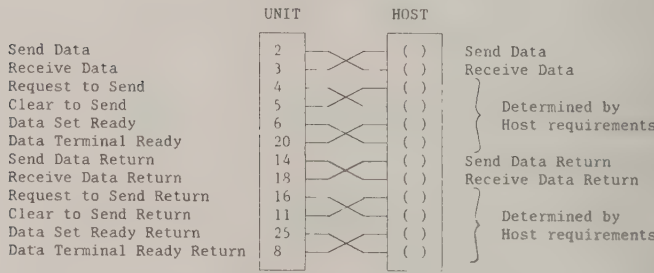


5.6 RS422 INTERFACE

RS422 HALF/FULL DUPLEX
WITHOUT HANDSHAKE

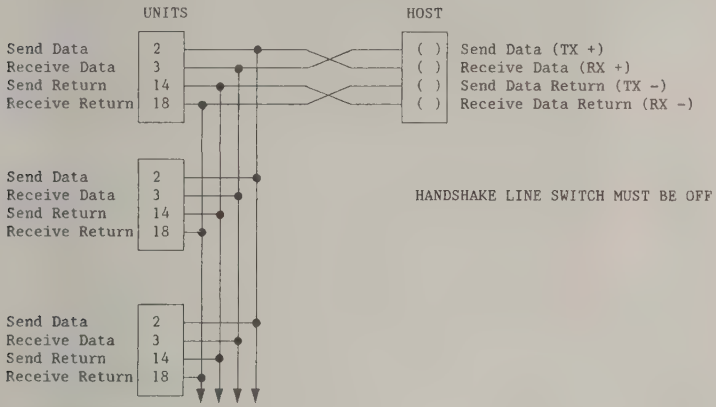


RS422 HALF/FULL DUPLEX
WITH HANDSHAKE

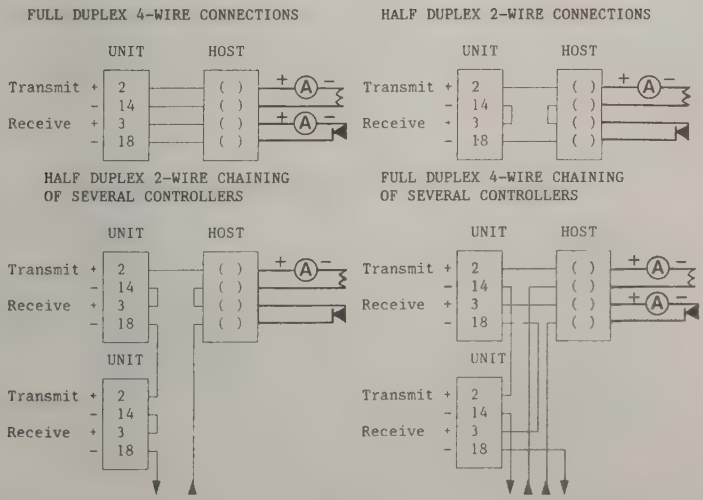


The RS422 driver is shown here. Be sure the Host RS422 driver conforms or it will be necessary to swap connections between all signals and their respective return lines to correct polarity--i.e., Pins 2 and 14, Pins 3 and 18, etc.

RS422 may be DROP LINE configured to enable the host to talk to several controllers through one port as shown.



5.7 20 mA CURRENT LOOP INTERFACE



5.7 20 mA CURRENT LOOP INTERFACE (CONT.)

NOTES: 1. Symbol A indicates 20 mA current source provided by others.

2. Less than 2.3 V (Transmit) and 1.0 V (Receive) drop across contacts while marking.

3. Maximum voltage that can be applied across Transmitter or Receiver Terminals is 24 V. Maximum current is 30 mA.

5.8 FORMAT SELECTION SWITCHES

Format selector switches mounted on the communications circuit board inside the controller allow the user to select Parity, Baud Rate and Unit Address to fit the application. The switch options are:

PARITY: Even, odd or no parity (factory set at NO PARITY)

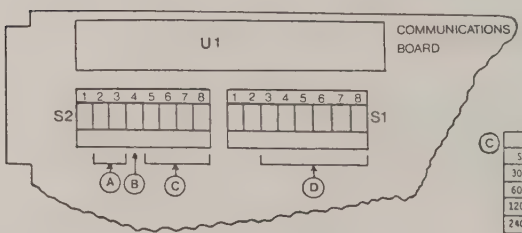
BAUD RATE: 300, 600, 1200 or 2400 (factory set at 1200)

UNIT ADDRESS: 0 to 63 (factory set at ADDRESS 0000)

Handshake: YES or NO (factory set at NO HANDSHAKE)

To access these switches, turn power to the controller OFF. Press in the tabs on each side of the front bezel and pull the electronic assembly forward enough to expose the switches. DO NOT REMOVE the assembly from the case.

Carefully note the type of switch action. Rocker switch action is PUSH IN to activate. Slider switch action is slide UP or DOWN to activate. Follow the markings on the switch for the correct switch position for ON (CLOSED, HI, 1) or OFF (OPEN, LO, 0). Use a pencil, pen tip or bent paper clip to set desired switch position.



A — PARITY

S2	2	3
NONE	OFF	OFF
ODD	ON	OFF
EVEN	ON	ON

B — HANDSHAKE

S2	4
NO	OFF
YES	ON

C — BAUD RATE

S2	5	6	7	8
300	ON	ON	OFF	OFF
600	OFF	OFF	OFF	ON
1200	OFF	OFF	ON	OFF
2400	ON	OFF	OFF	ON

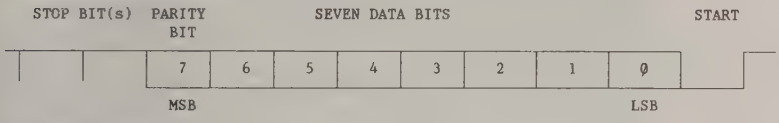
D — UNIT ADDRESS

S1	3	4	5	6	7	8
VALUE	32	16	8	4	2	1

ALL UNUSED SWITCHES MUST BE SET "OFF"

5.9 ASYNCHRONOUS SERIAL DATA FORMAT

The DATA WORD consists of one ASCII character, i.e., two hexadecimal characters plus one start bit and two stop bits. The number of incoming stop bits is not critical. The controller can accept any number of stop bits. The controller will always respond with two stop bits. The MSB of the data bits is the parity bit. When parity is not used the MSB must be OFF.



5.10 DATA PROTOCOL

The controller is always the passive listener in this protocol. Transmission is always initiated by the host computer. The host sends a command or a command and data to the controller. The controller responds within 100 ms. either with system status or with system status and data.

The COMMAND sent by the host must be all in upper case letters in the following format except that CKSUM is optional with the host. The controller will ignore a lack of CKSUM if none is provided by the host computer. The controller will always respond with a CKSUM even if it is not used. See Examples 5.16 and 5.17. The controller will not accept lower case letters.

TO READ DATA:

```
* UNIT# : R PARAMETER : CKSUM CR
```

TO WRITE DATA:

```
* UNIT# : W PARAMETER / DATA : CKSUM CR
```

Note: The Controller will ignore LF if transmitted after CR.

The Controller will respond within 100 ms. in the following format:

RESPONSE TO READ COMMAND:

```
$ STATUS : DATA : CKSUM CR LF
```

RESPONSE TO WRITE COMMAND:

```
$ STATUS :: CKSUM CR LF
```

Note: Spacing is included above purely for clarity. Actual data transmission must not include spacings. NULL characters HEX "ØØ" may be sent within the context of the message to the host from the controller and should be ignored, but must not be sent to the controller.

5.11 DATA PROTOCOL DEFINITIONS

*	- Standard ASCII character used by the host computer to initiate a command.
:	- Standard ASCII character used as a field separator.
/	- Standard ASCII character used as a separator between the PARAMETER mnemonic and the data in a WRITE command.
$	- Standard ASCII character used by the controller as the first character in a response.
UNIT #	- ASCII Ø to 63. The unit address Identification is set by means of binary weighted internal switches on the controller communications board. The unit address can be omitted in transmissions when only one unit is involved and address switches are set to all zeros. (See Section 5.8.)
R	- READ command
W	- WRITE command
PARAMETER	- Controller variable shown as a three-character ASCII mnemonic. ONLY UPPER CASE CHARACTERS MAY BE USED.
CKSUM	- TWO ASCII hexadecimal characters representing an eight-bit checksum formed by adding each byte of the string preceding the checksum into an eight-bit accumulator and ignoring any overflow. The resulting eight-bit sum is sent as two hexadecimal characters. The high order four bits are the first characters and the low order four bits are the last character. CKSUM is optional with the user.
CR	- Carriage Return
LF	- Line Feed
STATUS	- Two ASCII coded hexadecimal characters defining the system status.
DATA	- A string of ASCII digits, including minus sign where appropriate, representing the numerical value of the PARAMETER specified. Limited to four character spaces.

5.12 PARAMETER DESIGNATIONS

FUNCTION	MNEMONIC	DEFINITION	LIMITS: All values must be set in as whole numbers. See note (2) below.
Operator Functions	PVØ	Process Variable	Do not write to Process Variable
	CSP	Control Setpoint	Must be within span limits
	OP1	Output 1-PRImary	READ only except in MANUAL control (3)
	OP2	Output 2-SECondary	READ only except in MANUAL control (3)
	RPL	Repeats left-R&S	1 to 254 or 255 for continuous
	TML	Time left- R&S	HR:MIN or MIN:SEC (1)
Primary Control	DB1	Dead Band 1	25, 50 or 100 for % of SPAN (2)
	CT1	Cycle Time 1	1 to 60 for seconds of CYCLE TIME
	PB1	Proportioning Band 1	1 to 200 for % of SPAN
Output 1	RE1	Reset 1	1 to 2000 for R/M or Ø for RESET OFF (2)
	RA1	Rate 1	1 to 500 for Minutes or Ø for RATE OFF (2)
Secondary Control	ASP	Auxiliary Setpoint	Secondary setpoint must be within SPAN
	DB2	Dead Band 2	25, 50 or 100 for % of SPAN (2)
	CT2	Cycle Time 2	1 to 60 for seconds of CYCLE TIME
Output 2	PB2	Proportioning Band 2	1 to 200 for % of SPAN
	RE2	Reset 2	1 to 2000 for R/M or Ø for RESET OFF (2)
	RA2	Rate 2	1 to 500 for Minutes or Ø for RATE OFF (2)
Timers (Optional)	R1H	Relay 1 - Hours	0 to 999 for Hours or Minutes (1)
	R1M	Relay 1 - Minutes	0 to 59 for Minutes or Seconds (1)
	R2H	Relay 2 - Hours	0 to 999 for Hours or Minutes (1)
	R2M	Relay 2 - Minutes	0 to 59 for Minutes or Seconds (1)
Alarms	AL1	Alarm 1 - Setpoint	Must be within system span limits
	AL2	Alarm 2 - Setpoint	Must be within system span limits
Setpoint for Ramp & Soak Multiset-point Programs	SPØ	Setpoint Ø	ALL SETPOINTS MUST BE WITHIN SPAN
	SP1	Setpoint 1	
	SP2	Setpoint 2	
	SP3	Setpoint 3	
	SP4	Setpoint 4	
	SP5	Setpoint 5	
	SP6	Setpoint 6	
	SP7	Setpoint 7	
	SP8	Setpoint 8	
	SPP	POINTER	POINTER FOR SETPOINT SELECTION
Times for Ramp & Soak Program	TM1	Time 1	ALL TIMES IN HR:MIN or MIN:SEC (1) UP TO 99:59
	TM2	Time 2	
	TM3	Time 3	
	TM4	Time 4	
	TM5	Time 5	
	TM6	Time 6	
	TM7	Time 7	
	TM8	Time 8	
Ramp & Soak	RPT	Repeats	1 to 254 or 255 for continuous repeats
	ASK	Assured Soak Tol.	1 to 200 units tolerance
Status	PSW	Process Status	See Section 5.13 for details
	CSW	Control Status	See Section 5.14 for details

NOTES:

(1) TIMER can be set to operate in Hours:Minutes or Minutes:Seconds at the time of calibration. Set in selected time without colon, i.e., 9959 not 99:59

(2) Set in desired value as a whole number. Controller logic will multiply input by 0.01 to get correct decimal value.

(3) Output power is communicated as a digital value from 0 to 4095. To READ "% OUTPUT", divide the transmitted values by 40.95. Use this same rule to input any MANUAL control output values.

5.13 CONTROL COMMANDS - PROCESS STATUS (PSW)

The USER may READ or WRITE the Process Status (mnemonic PSW) as two ASCII HEX characters. Before WRITING a new command, you must first read the existing command data bits. All data bits you do not wish to change MUST be repeated in the new command including bits designated RESERVED.

DATA BITS	7	6	5	4	3	2	1	Ø
	MSB							LSB

BIT	Ø STATUS	1 STATUS
7	Stop	Start
6	Manual Control	Auto Control
5	Normal	Input Open (READ only)
4	Normal	Data Lost (READ only)
3	"REM" flashing	"REM" full on
2	ALM/Timer 2 OFF	ALM/Timer 2 ON
1	ALM/Timer 1 OFF	ALM/Timer 1 ON
Ø	Reserved	Reserved

5.14 CONTROL COMMANDS - CONTROL STATUS (CSW)

The USER may READ or WRITE the control status (mnemonic CSW) as two ASCII HEX characters. Before WRITING a new command, you must first read the existing command data bits. All data bits you do not wish to change MUST be repeated in the new command including bits designated RESERVED.

DATA BITS	7	6	5	4	3	2	1	Ø
	MSB							LSB

BIT	Ø STATUS	1 STATUS	
7	Reserved	Reserved	
6	Reserved	Reserved	
5	Reserved	Reserved	
4	Normal	Timer Override (Timers only)	
3	Normal	Assured Ramp & Soak	
2	Normal	Multisetpoint ON	} Mutually
1	Normal	Ramp & Soak ON	} Exclusive
Ø	Reserved	Reserved	

5.15 STATUS RESPONSE

Every command from the host computer causes the controller to generate a two ASCII HEX character status report as part of its response. Normal state (Ø) is assumed to be normal controller operation.

DATA BITS	T	C	S	D	P	R	A	U
	MSB							LSB

BIT	ABNORMAL CONDITION "1"
T	Transmission Error
C	CKSUM Error on received Data
S	Syntax Error or Illegal Input
D	Communications Turned OFF
P	Parity Error on received Data
R	INPUT OPEN
A	Alarm Condition (Relay 1 and/or Relay 2)
U	Reserved

5.16 PROTOCOL EXAMPLE - READ

A command to READ the measurement of Unit Number 23 would be:

READ COMMAND	*	23	:	R	PVØ	:	2B	CR

To initiate command
Unit Number 23
Separator
R for READ command
Mnemonic for Data
Separator
CKSUM
Carriage Return

The controller response to the READ command if the measurement were 542 degrees would be:

RESPONSE $ ØØ : 542 : 93 CR LF

To initiate response
Status
Separator
Requested Data
Separator
CKSUM
Carriage Return
Line Feed

CKSUM COMPUTATION IS AS FOLLOWS (for example in this section)

READ COMMAND CHAR	HEX	RESPONSE REPLY CHAR	HEX
*	2A	$	24
2	32	Ø	3Ø
3	33	Ø	3Ø
:	3A	:	3A
R	52	5	35
P	5Ø	4	34
V	56	2	32
Ø	3Ø	:	3A
:	3A		
TOTAL	22B	TOTAL	193

BINARY ØØ1Ø ØØ1Ø 1Ø11

DISCARD
1st HEX = 2
2nd HEX = B

BINARY ØØØ1 1ØØ1 ØØ11

DISCARD
1st HEX = 9
2nd HEX = 3

NOTE: Parity bits are not included in the CKSUM.

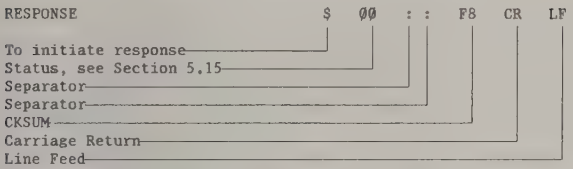
5.17 PROTOCOL EXAMPLE - WRITE

A command to WRITE (enter new data) into Unit Number 17 to make the setpoint 234 degrees would be:

WRITE COMMAND * 17 : W CSP/234 : ØB CR

To initiate command
Unit number 17
Separator
W for WRITE command
Mnemonic for setpoint
Separator
New Setpoint value
Separator
CKSUM
Carriage Return

The controller response to the WRITE command would be:



NOTE: The beginning of data and end of data (field) separators (:) will both be present even if status only (NO DATA) is being transmitted.

5.18 ASCII TABLE

ASCII - AMERICAN STANDARD CODE FOR INFORMATION INTERCHANGE

MSB / LSB		0000	0001	0010	0011	0100	0101	0110	0111	1000	1001	1010	1011	1100	1101	1110	1111
		0	1	2	3	4	5	6	7	8	9	A	B	C	D	E	F
0000	0	NUL	SOH	STX	ETX	EOT	ENQ	ACK	BEL	BS	HT	LF	VT	FF	CR	SO	SI
0001	1	DLE	DC1	DC2	DC3	DC4	NAK	SYN	ETB	CAN	EM	SUB	ESC	FS	GS	RS	US
0010	2	SP	!	"	#	$	%	&	'	(	)	*	+	,	—	.	/
0011	3	0	1	2	3	4	5	6	7	8	9	:	;	<	=	>	?
0100	4	@	A	B	C	D	E	F	G	H	I	J	K	L	M	N	O
0101	5	P	Q	R	S	T	U	V	W	X	Y	Z	[	\	]	^	—
0110	6	\	a	b	c	d	e	f	g	h	i	j	k	l	m	n	o
0111	7	p	q	r	s	t	u	v	w	x	y	z	{	l	}	~	DEL

BINARY — HEX — ASCII

SECTION 6 - CALIBRATION

6.1 CALIBRATION

The controller is delivered from the factory or distributor fully calibrated and ready to use. Recalibration is not normally required or recommended but it may be necessary in order to meet plant operating standard or to recover from extraordinary circumstances such as the DATA LOST/PLEASE CAL mode.

The term CALIBRATION in this controller includes both a CONFIGURATION procedure and a REFERENCE procedure. The CONFIGURATION procedure refers to those steps that must be performed to tell the microprocessor details of the application including input, output, control action, alarm, display units, span and time base. These details are to be keyed through the front keypad in a structured sequence. The REFERENCE procedure is the more traditional calibration using an external reference source. A structured program also exists for this calibration. A calibration loop flow chart in Section 7.4 is available to help explain the controller calibration.

Controller calibration can be performed at the normal controller installation or on a bench. Only AC power and an appropriate input are necessary. If an input calibrator is not available, a jumper between Terminals F and H is adequate for CONFIGURATION calibration. REFERENCE calibration requires a precise calibration source for the input signal. Be sure to cover AC power terminals.

CAUTION: COMPUTER DEVICES ARE NON-FORGIVING. KEY SEQUENCES AND INSTRUCTIONS MUST BE FOLLOWED PRECISELY. DO NOT SKIP ANY STEP. DO NOT TURN OFF POWER WHILE IN CAL LOOP.

6.2 ENTERING CALIBRATION PROGRAM

A security code protects the calibration procedure. To enter the calibration mode push the three keys as indicated in Figure 6-1 simultaneously. A front keypad "CAL" indicator will illuminate. If it does not, push the RETURN key and then push the 3 key code again.

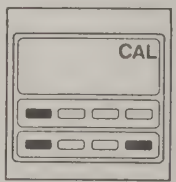


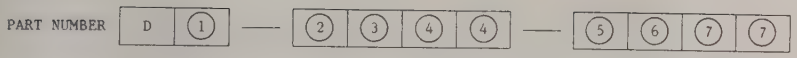
FIGURE 6-1

6.3 PART NUMBER

PN DX XX
XX XX XX

The PART NUMBER is the first CAL loop display. If this display does not appear, push the LAST key until it is on the display. This 10 digit PART NUMBER fully defines the controller.

This controller has been manufactured with specific hardware that determines its input and output capability. The PART NUMBER defines this capability. The PART NUMBER also defines some items that can be changed by a keypad instruction without any hardware change. For example: In a controller provided with thermocouple input, the type of thermocouple can be changed by a keypad instruction. However an input cannot be changed to an RTD or process input unless a hardware change is also made. CONFIGURATION calibration deal specifically with those items that can be changed strictly by a keypad instruction.



① Model	② Primary Output	④ Input	⑤ Alarm/Timer 1	⑦ Options
D0 2010 No communications	0 NO PRIMARY	00 J thermocouple	0 no alarm	00 No options
D1 2010 Remote Analog Setpoint	1 PRI HEAT SSR ON/OFF	01 K thermocouple	1 HI process	XX Any special Factory
D2 2011 RS232C non-isolated	2 PRI COOL SSR ON/OFF	02 R thermocouple	2 LO process	assigns final numbers
D3 2011 RS232C isolated	3 PRI HEAT SSR PROP	03 S thermocouple	3 HI deviation	
D4 2011 RS422 non-isolated	4 PRI COOL SSR PROP	04 T thermocouple	4 LO deviation	
D5 2011 RS422 isolated	5 PRI HEAT 4-20 mA DC	05 N thermocouple	5 ON Timer	
D6 2011 20 mA Current (isolated)	6 PRI COOL 4-20 mA DC	06 E thermocouple	6 OFF Timer	
	7 PRI HEAT 0-5 V DC	07 B thermocouple		
	8 PRI COOL 0-5 V DC	08 PLATINEL II T/C	⑥ Alarm/Timer 2	
		09 Ni / Ni 18% Moly T/C	0 no alarm	
③ Secondary Output		10 W5 Re / W26 Re T/C	1 HI process	
0 NO SECONDARY		11 W3 Re / W25 Re T/C	2 LO process	
1 SEC HEAT SSR ON/OFF		12 W / W25 Re T/C	3 HI deviation	
2 SEC COOL SSR ON/OFF		20 1° RTD 100 Ω PT	4 LO deviation	
4 SEC COOL SSR PROP		21 0.1° RTD 100 Ω PT	5 ON Timer	
6 SEC COOL 4-20 mA DC		40 0-5 volts DC	6 OFF Timer	
7 SEC. COOL 0-5 V DC		60 4-20 mA DC		

6.4 PART NUMBER CHANGES

The following list defines allowable part number changes for the part number table shown above.

DIGIT 1 : Any number change requires a hardware change too.

DIGIT 2 : Numbers 1, 2, 3, 4 are interchangeable by keypad instruction.
Numbers 5 and 6 are interchangeable by keypad instruction.
Numbers 7 and 8 are interchangeable by keypad instruction. change.
Any other change requires a hardware change too.

DIGIT 3 : Numbers 1, 2, 4are interchangeable by keypad instructions only.
Any other changes require a hardware change too.

DIGIT 4 : Numbers 00 thru 12 are interchangeable by keypad instructions.
Any other changes require a hardware change too.

DIGIT 5 : All numbers except 0 are interchangeable by keypad instruction.

DIGIT 6 : All numbers except 0 are interchangeable by keypad instruction.

DIGIT 7 : This number is used to identify specials and should only be changed by authorized personnel.

Most recalibration requirements will use the original part number found on the instrument labels. If you make a change in the PART NUMBER, be sure you write the new number down on the back cover of this manual for future reference.
If you do not need to reset or change the part number push, the PARAM CHECK key to advance the display and proceed to paragraph 6.6.

If you do want to change the part number, proceed with paragraph 6.5.

6.5 SETTING THE PART NUMBER

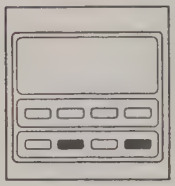


FIGURE 6-2

An additional security code protects the part number. To change the part number push the two keys indicated in Figure 6-2 simultaneously. (AUTO/MANUAL and LAST)

A flashing digit will appear at the first digit position. The digit that is flashing can be changed by using the arrow keys. The PARAM CHECK key advances the flashing digit and the LAST key backs up the digit. You can change any of the part numbers within the rules stated inparagraph 6.4. Be very careful not to enter an illegal part number.

If you are recovering from the DATA LOST mode be sure to enter the complete part number. When the part number is correct push the PARAM CHECK key until the next display appears.

6.6 SETTING THE DISPLAYED UNITS

The controller will accept any 2 alphanumeric characters for displayed units. The only limitation is that the temperature F or C units MUST be in the right hand position.

UNITS XX
TIME H:M

The best way to see how units are set is to push an arrow key while watching the display. All numbers and letters are available in both positions. UNITS setting starts with the left hand digit. Push the PARAM CHECK key to move to the right hand digit. The LAST key will back up right to left if needed. The DOWN key will scroll the digit reverse to the UP key. A blank is available in the sequence for single character units. The left hand position can be a blank. Push PARAM CHECK key when units are correct.

IMPORTANT NOTE: Changing units between F and C does not convert the numerical values of any setpoints, alarms, or span limits. Each setpoint, alarm and span limit must be individually changed to correspond to the new units of measurement. When no units are specified the controller uses the degree C linearization table for thermocouple or RTD input.

6.7 SETTING THE TIME BASE

A time base must be selected when a TIMER alarm or the RAMP & SOAK (Model 2015) program is included.

UNITS XX
TIME H:M

You can select Hours:Minutes (H:M) or Minutes:Seconds (M:S) for the time base. Push the NO key to change the selection. When the time base is correct, push the PARAM CHECK key to advance to the next display.

6.8 SETTING THE SPAN

LO SPAN
XXXX XX

The next two displays are LO and HI span. Span is the LO and HI limits outside of which the system is not to operate. The controller automatically limits all setpoints and alarms to be within this span.

HI SPAN
XXXX XX

The controller stores in permanent memory the maximum allowable spans for all listed thermocouples and RTD inputs. Unless ordered otherwise, the maximum span will appear on these displays. You can select any span up to the stored limits for thermocouple and RTD inputs. Push the UP arrow to read the maximum programmed limit.

Process type inputs are limited to any span between -3200 and +3200 units. You can assign any display value to the LO SPAN and HI SPAN within these limits and the controller will automatically linearize all values in between. Use the arrow keys to change values. Advance from LO to HI SPAN using the PARAM CHECK key. The LAST key will back up from HI to LO SPAN. Both direct and reverse spans are allowable.

CONFIGURATION calibration for controllers with thermocouple or RTD input is now complete. If you have this type of controller proceed to paragraph 6.11.

If you have a process input controller, three more displays are available. Push the PARAM CHECK key and proceed to Section 6.9.

6.9 SETTING THE DECIMAL POINT

DECIMAL
PLACES X

This display allows the selection of decimal point position from zero (no decimal point) to the third place from the right (i.e., 0.783). Use the arrow keys to select the decimal point position. When the decimal position is correct, push the PARAM CHECK key to advance to the next display.

6.10 SETTING THE DISPLAY RANGE

LO VAL
XXXX UU

This display is used to program the desired display indication at minimum input. For example: LO VAL can be set to indicate 0 for a 4 mA input level. After setting the desired reading using the arrow keys, press the PARAM CHECK key.

HI VAL
XXXX UU

This display is used to program the desired display indication at the maximum input. For example: HI VAL can be set to indicate 2000 for a 20 mA input level.

The LO VAL/HI VAL procedure is the electronic equivalent of changing the scale in an analog panel meter. No input reference calibration is required. You can change the displayed range entirely through the keypad when a process signal such as 4-20 mA is the input.

6.11 REFERENCE CALIBRATION

At this point in the calibration program the CONFIGURATION calibration has been completed. Three situations may exist.

a) You have completed what you need to do and wish to return the controller to use. Push the PARAM key and proceed to section 6.16.

b) The controller will not advance when you push the PARAM key. Proceed with the following instructions. This occurs usually when calibrating after a DATA LOST/PLEASE CAL.

c) You wish to perform a REFERENCE calibration. Proceed with the following instructions.

CAUTION: ENTRY INTO THE REFERENCE CALIBRATION ROUTINE WITHOUT PROPER CALIBRATION EQUIPMENT MAY ERASE THE FACTORY CALIBRATION. DO NOT PROCEED WITH THESE INSTRUCTIONS UNTIL YOU ARE PROPERLY PREPARED.

REFERENCE calibration refers to the procedure for calibrating the controller to an external input reference source. Before starting a reference calibration you must be at one of these displays.

HI SPAN XXX	OR	HI VAL XXX

If you are not at one of these displays and wish to do a REFERENCE calibration push the PARAM CHECK key until "CAL COMPLETE" appears. Then push the LAST key once.

A security code protects the reference calibration procedures. To enter the reference calibration mode push the two keys indicated in Figure 6-3 simultaneously. (AUTO/MANUAL and STOP/START)

CAUTION: ALLOW AT LEAST A 20 MINUTE WARMUP BEFORE ANY REFERENCE CALIBRATION IS ATTEMPTED.

FIGURE 6-3

There are three stored calibration routines. The controller will automatically display the correct instructions for your application.

6.12 Thermocouple Input calibration
6.13 RTD Input calibration
6.14 Process Input calibration

6.12 THERMOCOUPLE CALIBRATION

All thermocouple input controllers are calibrated in the same manner. A 50.000 mV source, and a J T/C in an Ice Bath are required.

IMPORTANT NOTE: A cold junction compensator resistor is provided at the rear terminals of each thermocouple input controller. Calibration of thermocouple units MUST be done with the specific compensator to be used in the final installation. All thermocouple input controllers are calibrated with a type J thermocouple.

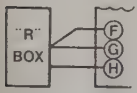
INPUT 50.000MV

This display indicates that a stable, precision noise free 50.000±.005 mV DC calibration source be connected to the rear case terminals F (-) and H (+). Allow a two minute interval for the input circuit to stabilize with the 50.000 mV applied and then push the PARAM CHECK key.

J T/C IN ICE BATH

Without removing the AC power, change the input to a J type thermocouple in an Ice Bath. Allow a 2 minute interval for the input circuit to stabilize and then push the PARAM CHECK key. Proceed to Section 6.15.

6.13 RTD CALIBRATION



RTD input controllers should be calibrated using a precision decade resistance. Be sure to use short, low resistance leads and good tight connections. Three wire connections to the input are required to minimize lead resistance errors. All wires must be the same gauge and length.

INPUT 100 OHMS

This display is the first step for RTD calibration. Connect the RTD resistance box and set for 100.00±.05 Ω. Allow a 2 minute interval for the input circuit to stabilize and then push the PARAM CHECK key.

INPUT 300 OHMS

Set the RTD resistance box for 300.00±.05 Ω. Allow a 2 minute interval for the input circuit to stabilize and then push the PARAM CHECK key. For controllers with 0.1° RTD resolution, different inputs may be specified. Proceed to Section 6.15.

6.14 PROCESS CALIBRATION

An appropriate voltage or current source is required for process input calibration.

INPUT LO CAL

This display is the first step for process input calibration. Connect the calibrator and set its output to the LO calibration value. With a 4-20 mA input, the LO CAL would be 4 mA. Allow a 2 minute interval for the input circuit to stabilize and then push the PARAM CHECK key.

INPUT HI CAL

Adjust the calibrator to output the HI calibration value. With a 4-20 mA input, the HI CAL would be 20 mA. Allow a 2 minute interval for the input circuit to stabilize and then push the PARAM CHECK key.

6.15 REMOTE SETPOINT CALIBRATION

REMOTE SETPOINT Input can be used in any controller that has been provided with this option. Perform all other calibrations before proceeding with this calibration. If REMOTE SETPOINT is not included, the display will automatically advance to CAL COMPLETE Section 6.16.

To calibrate the Remote Setpoint Input enter the reference calibration program as described in Section 6.11 and advance to the following display using the NO key. DO NOT PUSH THE PARAM CHECK KEY. THIS IS IMPORTANT. If you use the PARAM CHECK key, you will erase the input reference calibration. Use the NO key to bypass the input reference calibration to get to the Remote Setpoint Calibration.

INPUT LO REMSP

Connect the remote voltage or current calibration source to terminals B (+) and A (-) or use the internal +2.45VDC across terminals C and A to power a remote 10K Ω potentiometer with the arm connected to terminal B.

Set the input source to the LO INPUT value that is to correspond to the LO SPAN value that previously established. Wait 2 minutes for the system to stabilize and then push thePARAM CHECK key.

INPUT HI REMSP

Set the input calibration source to the HI INPUT value that is to correspond to the HI SPAN value previously established. Wait 2 minutes for the system to stabilize and then push the PARAM CHECK key. Proceed to Section 6.16.

6.16 CALIBRATION COMPLETE

CAL COMPLETE

This is the final display in the calibration program. When at this display, you must push the RETURN key to enter and store all calibration data. THIS STEP IS CRITICAL. All the changes and references are not valid until this step is completed. When you push the RETURN key, the controller returns to the OPERATOR mode and the CAL indicator goes out.

You can now remove the calibrator and reconnect the controller to its normal input.

SECTION 7 - FLOW CHARTS

7.1 FLOW CHARTS

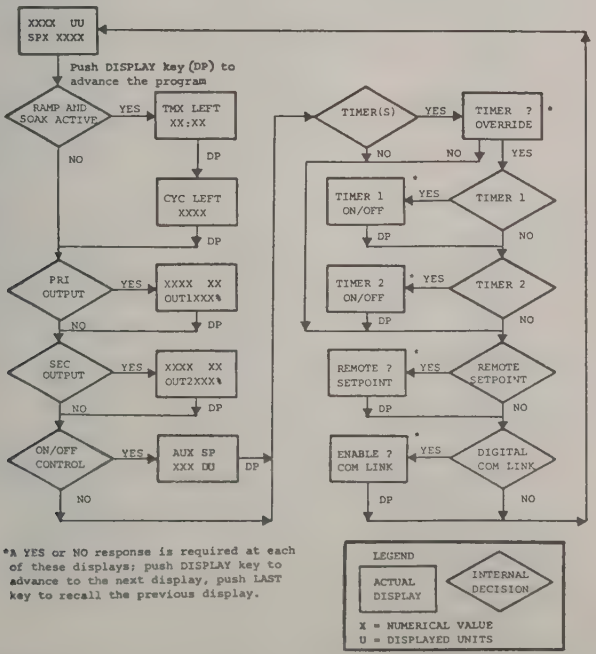
The following flow charts are provided to assist you in understanding the sequence of displays available to you. The rectangular boxes are reproductions of the actual alphanumeric displays. You can follow the flow chart as you push the appropriate keys on your controller.

For Example: In the TUNE loop, flow chart 7.3, you can scroll through the entire Tune program simply by pushing the appropriate keys. If you do not change any tuning values, scrolling through the loop will have no effect on the controller.

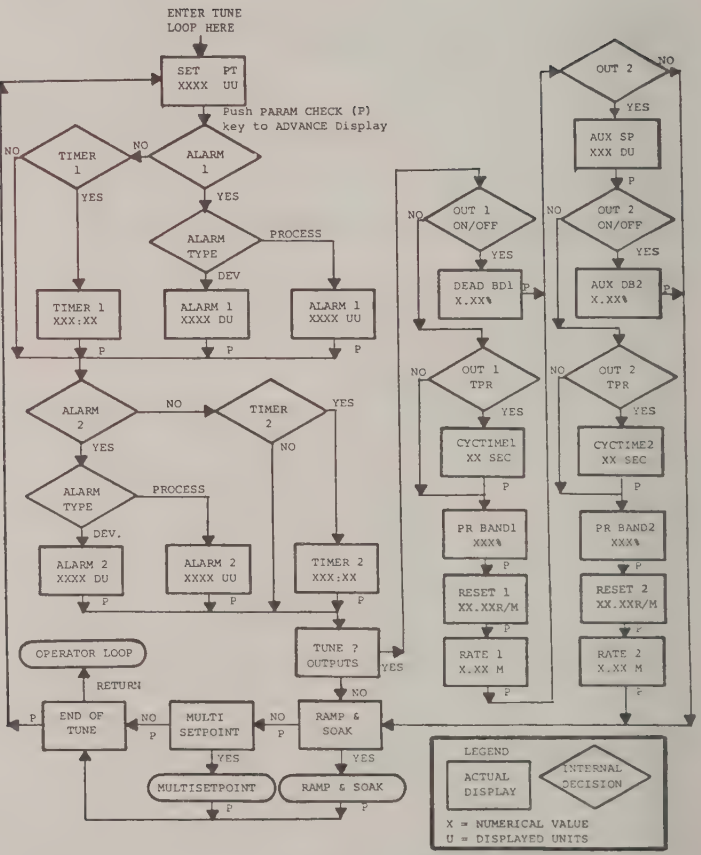
The CALIBRATION loop, flow chart 7.4, should be used only by those qualified to calibrate the controller.

CAUTION: DO NOT ENTER THE CALIBRATION LOOP UNLESS QUALIFIED AND EQUIPPED FOR CALIBRATION.

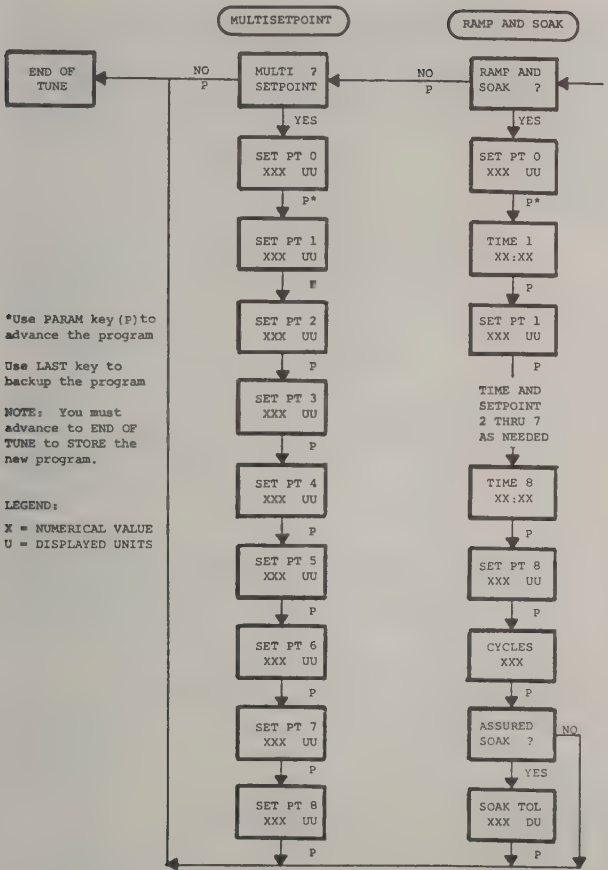
7.2 THE OPERATOR FLOW CHART



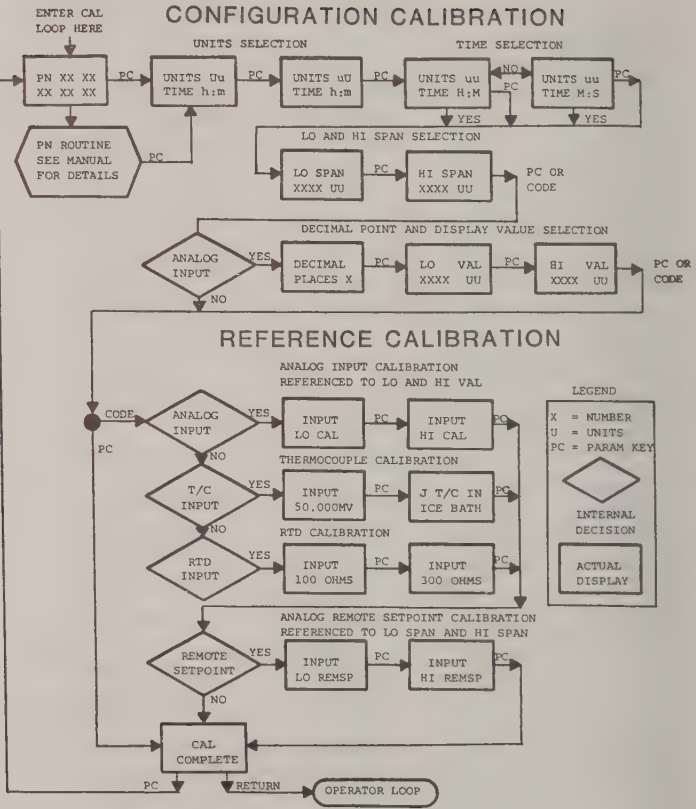
7.3 TUNE FLOW CHART



7.3A TUNE FLOW CHART PROGRAMMABLE OPTIONS



7.4 THE CALIBRATION FLOW CHART



CAUTION: DO NOT TURN OFF POWER WHILE IN CAL LOOP.

SECTION 8 - SERVICE

8.1 SERVICE

If you experience difficulty with a controller, first check all wiring. Also pull the electronic assembly forward out of the case enough to check that all circuit boards and plug-in components are snugly in their connectors.

Check that the correct key sequence has been used and that the setpoints and tuning values set into the controller are appropriate to the application.

8.2 DIAGNOSTIC DISPLAYS

The controller contains several self-diagnosis programs that will display an appropriate warning when necessary. When any of these displays appear the control output(s) go OFF and the alarm(s) go ON.

INPUT OPEN	This display indicates that the input is an open circuit and must be corrected before proceeding.
POWER FAILURE	This display will appear if the AC voltage to the controller drops below specification to a low voltage level. Check the AC voltage level and correct if necessary.
RTC FAILURE RAM FAILURE	If either of these displays appear, try switching the AC power OFF or ON to the controller. If the indication stays the same, the controller must be serviced by authorized personnel.

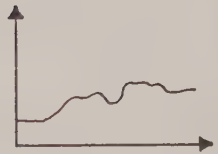
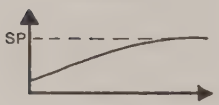
8.3 DATA LOST

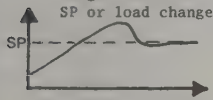
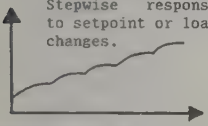
DATA LOST PLEASE CAL	These alternating flashing displays indicate that, for some reason, the controller calibration has been lost. This is an error alarm that prevents the controller from continuing to operate after an error is detected in the internal memory. When these displays appear, the controller shuts down.

Recalibration is a quick and easy procedure which is fully explained in Section 6. You can recalibrate the controller by following these instructions or you can return the controller to the factory or authorized distributor for recalibration

8.4 TROUBLESHOOTING GUIDE

SYMPTOM	CAUSE	CORRECTION
Power applied, display does not light and controller does not operate.	a) No power applied to controller. b) Controller not engaged properly in housing.	a) Check power wiring and fusing. b) Check if controller is properly engaged in housing.

SYMPTOM	CAUSE	CORRECTION
No power to load Measurement indicates temperature below setpoint. Output indicator is on continuously.	a) Open connection to load.	a) Check load wiring and load fuses. b) Check load connections.
Erratic Control 	a) Cycle time is too long. b) Proportional band is too narrow. c) Rate time is too short.	a) Reduce cycle time. When using electromechanical relay or contactor, set cycle time at value just below point where load cycling occurs. b) Increase PB adjustment until load cycling is eliminated. c) Increase rate time adjustment.
Controller operating not at setpoint and calling for 100% power.	a) System dynamics requires more Time. b) Improper sizing of source to load.	a) Wait for process to reach setpoint. b) Larger source is required.
Display shows Input open.	Thermocouple, RTD or input circuit open.	Check thermocouple and extension wire in circuits for opens.
Inability to tune controller properly.	a) On controllers with dual 3-mode outputs, resets and rates for both outputs must be set to zero before beginning the tuning procedure. b) Cycle time is set too long.	a) In tuning procedure outlined previously, the rate and reset adjustments are set to zero (turned off). b) Reduce cycle time.
Slow response to setpoint or load change with tuned controller. 	Reset time is set too short.	Increase the resets/minute (R/M) and recheck response by making a small setpoint change.

SYMPTOM	CAUSE	CORRECTION
 Large overshoot on SP or load change.	Reset time is set too long.	Decrease the reset and recheck response by making a small setpoint change.
 Stepwise response to setpoint or load changes.	Rate time is set too long.	Decrease rate time setting and recheck response by making a small setpoint change.

8.5 SERVICING /MODIFICATION

If repair is required, the complete instrument should be adequately packed. Do not send the electronic assembly without its case. Include a brief note describing the observed problem and shipped prepaid to the nearest Modification Center, or:

LFE Corporation - Repair Department
11655 Chillicothe Road
Chesterland, Ohio 44026-1994
(216) 729-1681
FAX (216) 729-2111

8.6 WARRANTY

LFE Corporation warrants equipment of its manufacture against defect in material and workmanship for a period of one year from date of shipment. LFE Corporation's obligation under this warranty is expressly limited to the repairing or replacing at its factory or at any authorized repair station equipment returned provided that (a) LFE Corporation is promptly notified in writing by the Buyer upon his discovery of a defect, (b) Upon receipt of written authorization from LFE Corporation said defective equipment is returned as directed, with transportation charges prepaid by the Buyer, and (c) LFE Corporations examination of such equipment discloses to its satisfaction that the defect exists and was not caused by negligence, misuse, improper installation, accident or unauthorized repair or alteration by the customer.

This warranty does not cover mechanical parts failing from normal usage nor does it cover limited life electrical components which deteriorate with age.

THIS WARRANTY IS IN LIEU OF ALL OTHER WARRANTIES, EXPRESSED OR IMPLIED, INCLUDING THE IMPLIED WARRANTY OF FITNESS FOR A PARTICULAR PURPOSE WHETHER TO THE ORIGINAL PURCHASER OR TO ANY OTHER PERSON. LFE CORPORATION SHALL NOT BE LIABLE FOR CONSEQUENTIAL DAMAGES OF ANY KIND.

The aforementioned provisions do not extend the original warranty period of any article which has been either repaired or replaced by LFE Corporation. LFE Corporation shall not be bound by any terms, conditions, representations or warranties, express or implied, which are not stated herein.

APPLICATION INFORMATION

APPLICATION: _____

LOCATION: _____

MACHINE ID: _____

CONTROLLER ID: _____

SENSOR TYPE: _____

CONTROLLER PART NUMBER: (Read 10 digit part number from part number label)

D		—					—				

SPAN: _____

DISPLAY RANGE: _____ DISPLAY UNITS _____

PRIMARY OUTPUT: ( ) HEAT ( ) COOL
( ) TIME PROPORTIONAL ( ) ANALOG ( ) ON/OFF

SECONDARY OUTPUT: ( ) NONE ( ) HEAT ( ) COOL
( ) ON/OFF ( ) TPR ( ) ANALOG

RELAY 1: ( ) ALARM ( ) TIMER SET TO: _____

RELAY 2: ( ) ALARM ( ) TIMER SET TO: _____

TUNING VALUES	PRIMARY OUTPUT	SECONDARY OUTPUT
Dead Band	_____% Span	_____% Span
Cycle Time	_____min.	_____min.
Proportioning Band	_____% Span	_____% Span
Reset	_____R/M	_____R/M
Rate	_____min.	_____min.

OPTIONS:

( ) DIGITAL COMMUNICATIONS ( ) RS232C ( ) RS422 ( ) 20mA LOOP
( ) REMOTE SETPOINT
( ) REMOTE START/STOP
( ) _____

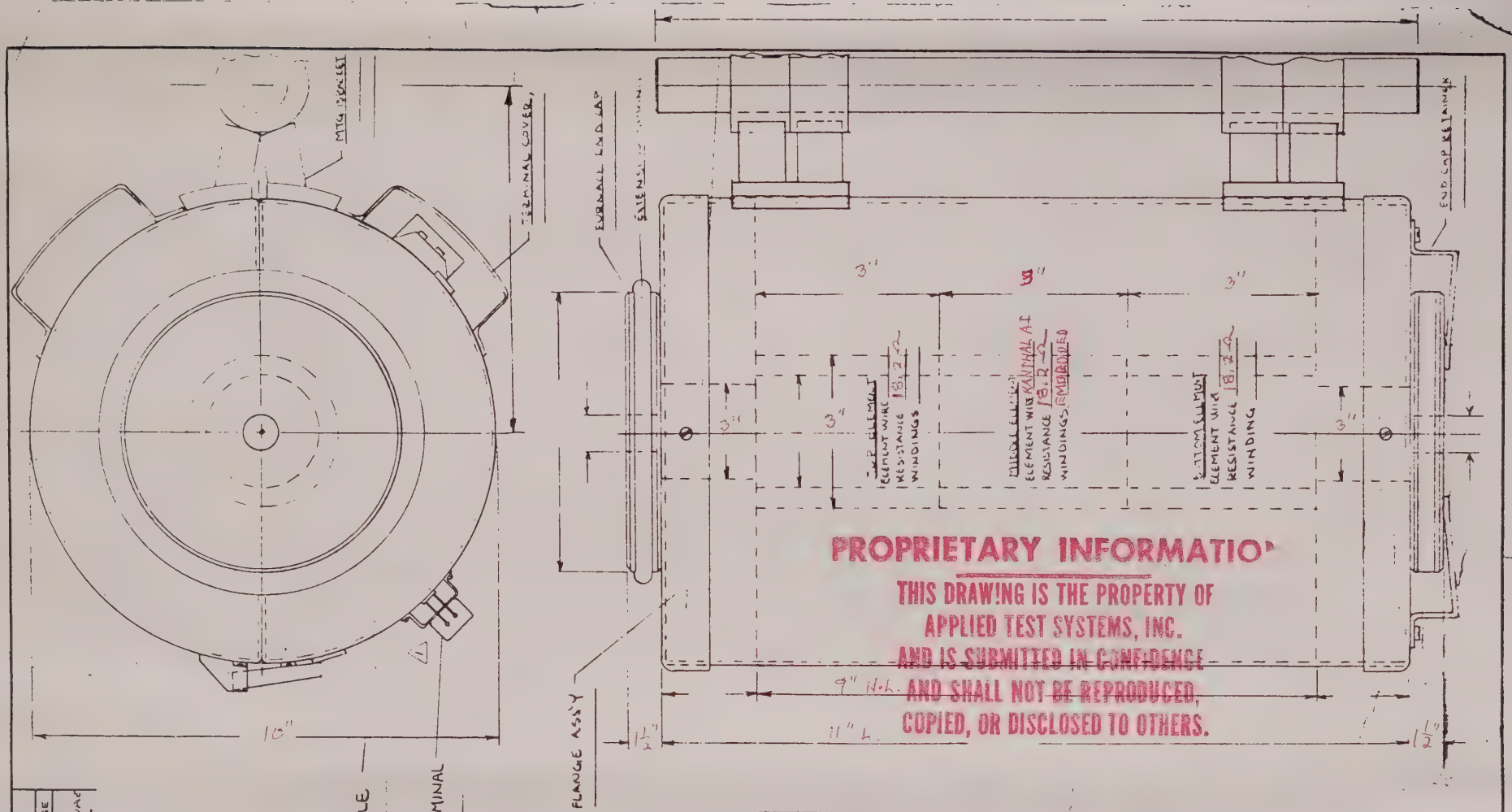
SERVICE HISTORY:

DATE: _____ ACTION: _____

_____ _____

_____ _____

INSTALLED BY: _____ DATE: _____



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AND SHALL NOT BE REPRODUCED,
COPIED, OR DISCLOSED TO OTHERS.

REVISIONS		
NO.	DATE	CHANGE
1	11-2-78	CHANGED THERMOCOUPLE TERMINAL

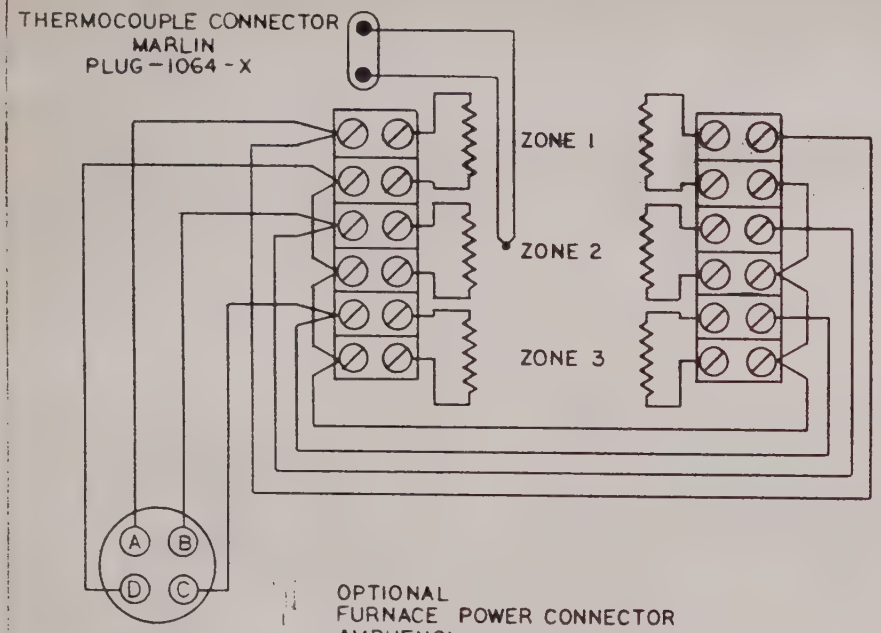
MACHINING TOLERANCES UNLESS OTHERWISE SPECIFIED			
DIMENSIONS	UNDER 6	6–18	OVER 18
DECIMAL DIM'S	± .005	± .005	± .010
FRACTIONAL DIM'S	± 1/64	± 1/32	± 1/16
FINISH (✓)-AA-125 MICRO IN		ANGLES ± 1/2°	
THREADS - UNIFIED CL 2A - 2B		CHAMFERS ± 5°	
FILLETS-1/64 TO 1/32		DRILLED HOLE ± .005	
BREAK CORNERS-1/64 MAX R OR CHAMFERS			

APPLIED TEST SYSTEMS, INC.

SERIES 2961 SPLIT TEST FURNACE
ASSEMBLY DATA

DR. D BEBLO	APP.	
ORDER NO.	M.H.A.:	2-1287
DATE 6-27-74	SCALE ½" = 1'	REV. 1

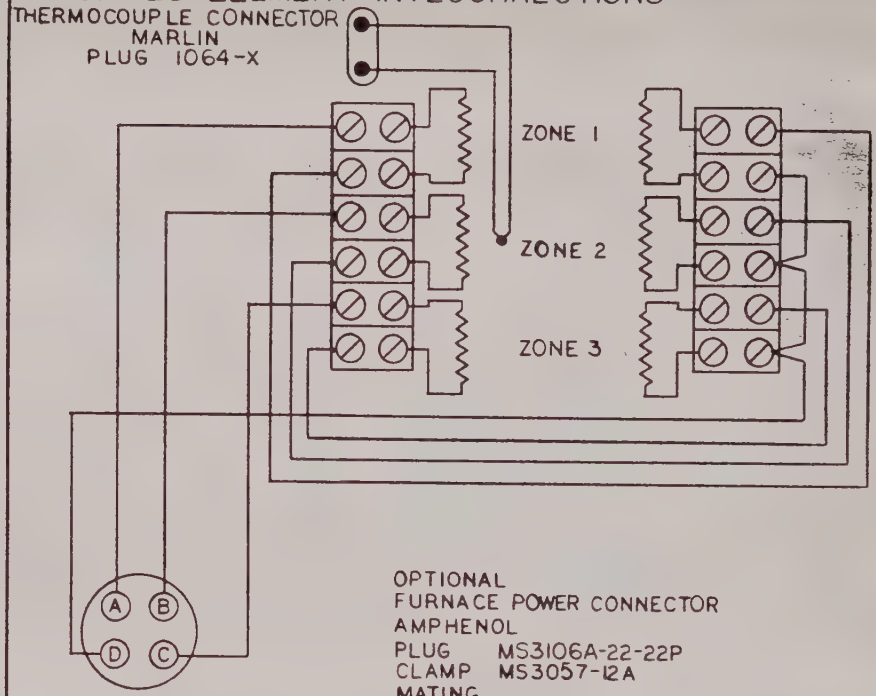
PARALLEL ELEMENT INTERCONNECTIONS



PIN A - ZONE 1
PIN B - ZONE 2
PIN C - ZONE 3
PIN D - COMMON

OPTIONAL
FURNACE POWER CONNECTOR
AMPHENOL
PLUG MS3106-22-22P
CLAMP MS3057 - 12A
MATING
RECEPTACLE MS3102A-22-22S

SERIES ELEMENT INTECONNECTIONS



PIN A - ZONE 1
PIN B - ZONE 2
PIN C - ZONE 3
PIN D - COMMON

OPTIONAL
FURNACE POWER CONNECTOR
AMPHENOL
PLUG MS3106A-22-22P
CLAMP MS3057-12A
MATING
RECEPTACLE MS3102A-22-22S

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REVISIONS		
NO.	DATE	CHANGE
A	9-26-87	REDRAWN FOR ROM CLARITY

MACHINING TOLERANCES UNLESS OTHERWISE SPECIFIED			
DIMENSIONS	UNDER 6	6 TO 18	OVER 18
DECIMAL DIM'S	± .005	± 0.5%	± .010
FRACTIONAL DIM'S	± 1/64	± 1/32	± 1/16
FINISH - 63 AA 125 MICRO IN		ANGLES - ± 2°	
THREADS - UNIFIED CL 2A - 2B		CHAMFERS - 45°	
FILLETS 1/64 TO 1/32		DRILLED HOLE ± .005	
BREAK CORNERS 1/64 MAX R OF CHAMFERS			

APPLIED TEST SYSTEMS, INC.

FURNACE WIRING DIAGRAM
PARALLEL + SERIES ELEMENT INTERCONNECT

DR R. MURPHY	APP	2-1500	
DRFR	M F A		
DATE 9-26-87	SCALE	SH 2	

THE MARK OF RELIABILITY
APPLIED TEST SYSTEMS, INC.
348 New Castle Road • P.O. Box 1529 • Butler, PA 16003
Telephone: 412/283-1212 • Telex: 86-6727 ATS BUTLER

WARRANTY POLICY

Applied Test Systems, Inc. warrants equipment of its own manufacture against defects in material and workmanship for a period of one (1) year from date of shipment.

ATS's obligation under this warranty is expressly limited to the repairing or replacing at its factory, or at any authorized repair station, equipment returned, provided -

a) ATS is promptly notified in writing by the Buyer upon his discovery of the defect.

b) Upon receipt of written authorization from ATS, said defective equipment is returned as directed, with transportation charges prepaid by the buyer and

c) ATS's examination of such equipment discloses to its satisfaction that the defect exists and was not caused by negligence, misuse, improper installation, accident, or unauthorized repair or alteration by the buyer.

Warranties for standard products as manufactured by our suppliers of refractories and insulation will be extended when available, otherwise warranties for these products cannot be offered. This warranty does not cover limited life mechanical parts failing from normal usage, nor does it cover limited life electrical components which deteriorate with age such as tubes, lamps, fuses, heaters, etc. Applied Test Systems reserves the right to change published specifications.

This warranty is in lieu of all other warranties, expressed or implied, including the implied warranty of fitness for a particular purpose, whether to the original purchaser, or for any other reason. ATS shall not be liable for collateral or consequential damages.

The aforementioned provisions do not extend the original warranty period of any article which has been either repaired or replaced by Applied Test Systems, Inc.

5/1/84 NLC

ACCOPRESS®

25070	YELLOW
25071	BLACK
25072	LIGHT BLUE
25073	DARK BLUE
25074	LIGHT GRAY
25075	LIGHT GREEN
25076	DARK GREEN
25077	TANGERINE
25078	RED
25079	EXECUTIVE RED

WITH WATER RESISTANT

PRESSTEX®

COVERS

ACCO

ACCO INTERNATIONAL INC
CHICAGO, ILLINOIS 60619

MP MASTER
MA32801